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NOTES FROM THE JOURNAL OF LIEUTENANT T. A. M. CRAVEN, U. S. N.

U. S. S. DALE, PACIFIC SQUADRON, 1846–49.

II.*

January 29, 1847.—Sailed from Monterey for Panama, via Santa Barbara, San Pedro, and San Diego, three small ports on the coast of Upper California, into each of which we peeped, and in none found anything of note save at San Diego where the Congress was lying at anchor. The passage to Panama was long and tedious; we arrived March 15, and left on the 28th for Monterey, and reached the latter port May 23, finding the Columbus and Warren and several trading vessels at anchor. The place is busier and more active than when we left; indeed, then it had the appearance of a deserted village; now it begins to show some signs of life and activity; quiet has been restored, people have returned to the cares of their affairs, and the

* Concluded from No. 44, p. 148.

increase of our squadron, with the arrival of troops, stores and munitions of war, all cause quite a stir in the little town. The country around is now decked in all its beauty; endless varieties of flowers, of the gayest colors, cover the hillsides and valleys. Acres upon acres of lupines, yellow, white, blue, purple, and variegated, of all tints and descriptions, may be seen, whose tops are higher than my head when on horseback—say eight feet high. How rich and beautiful they are!

I went on a deer hunt last week with a small party, mustering five in number. We left the town about noon, and rode some fifteen miles through the most lovely country, when we reached a romantic spot in a deep glen, a basin, from which flowed a stream of delicious water. A deserted Indian wigwam stood under some magnificent trees, and here we resolved to encamp for the night. Before our camp-fire was lighted, one of our party brought in a fine buck, which was soon dressed in hunter's style, and there on the grass we supped and slept in quiet. We kept our fire through the night, and as day dawned breakfasted, mounted our steeds and started for the chase. After a weary day's ride I returned to the ship quite satisfied with my first hunt. I had but one shot, and as is the case with all on first seeing a deer, I stopped to look for a moment at the graceful animal as it bounded off, and on coming to my senses, fired without dismounting from my horse, and the deer kept on unharmed.

June 10.—One who has never seen the Spaniards nor the descendants of that proud race can have but little idea of the state of degradation to which they are now reduced. As I look upon them in the various parts of the world where we have met, a feeling of melancholy always comes upon me. The haughty Spaniard is sunk beneath the yoke of superstitious tyranny and ignorance, till, bruised as he is, you cannot recognize in him the son of that fair land once glorious in the pages of history. These reflections have come upon me while considering the condition of the degraded race who have possessed this California soil, and from whom it has now been wrested by the descendants of the Anglo-Saxon.

California is a beautiful country, well adapted for grazing, and its valleys should abound in fertility; but the people have been so lazy, their method of cultivation so slovenly, that but little more has been reaped than the natural productions of the soil, and scarcely the half of that. Cattle run wild and fatten on the oats which abound in the mountains; immense droves of horses are seen in the plains; but the

slothful son of Mexico, wrapped in his *serape*, lounges about the streets with his cigareta in his mouth, puffing away care and forgetting that he is human. Too lazy to work, he robs the industrious and spends his ill-gotten gains in the gambling house.

Here we are in the bay of Monterey. Beef is plenty, because it will thrive without care, but our own men have to kill it. Vegetables are an unknown luxury; beef and bread from one year's end to the other; a few miserable cabbages are brought in and sold for 12½ cents each; a small mess of beet tops brings the same price—and these are all the vegetables. Some of the Americans lately settled here have planted gardens and will soon enjoy abundant returns. The Mexican looks on in contemptuous silence and puffs his cigareta, or mounting his steed, dashes off like the wind and, like the Arab of the desert, imagines himself lord of the soil. There was no money in the country before we came; business was carried on by trade. The rancheros came to the seaport to buy clothing, etc., bringing with them hides and tallow. A hide worth one dollar and a half would purchase a yard and a half of calico, and that is the way they have lived. Money is now more plentiful, and the necessaries of life are becoming cheaper, but still the discontented Mexican shrugs his shoulders and wishes for a change, though that change be a relapse into the recent poverty and degradation of the place. The truth is the natives are impatient of law and order; so long have they been turbulent and unruly that they cannot bear the restraints which wholesome government will impose upon them.

I was much struck with the contrast between our own race and the Spaniard the other day while on my walk on shore. I went to a brickyard just started by three industrious Americans, who, with two boys, were hard at work and seemed to have no time to talk. They make 4000 bricks per day, and expect to burn a kiln of 100,000 per month; have already got orders for 300,000 bricks at $15 per thousand. I now went to an adjoining place where, after the manner of the ancients, two lazy Californians, who worked as if they had a thousand years ahead of them, were making adobes. Full glad were they to drop their work and talk. I asked how many adobes they made in a day. "Two hundred in a long day." "And what are they worth?" "Two dollars a hundred." Here, said I, is the Spaniard in contrast with the descendants of the enterprising Saxon. The former makes bricks as the Israelites made them in Egypt, and earns two dollars per day; a Yankee, within one hundred

yards of them, makes bricks as Yankees make them and earns more than five times the amount, while making a better and more durable article.

June 22.—Arrived at Saucelito, bay of San Francisco, and on July 18 sailed for Monterey, and had hardly anchored there ere summoned away to the southward. A revolt had broken out among the troops at Santa Barbara, and the Governor went down in our ship to suppress it. On arriving we found that the affair had been greatly exaggerated. Some trivial offenses had been committed, and the culprits were brought before a court-martial for trial and punishment; meanwhile we spent a week tolerably pleasantly, as the change from Monterey was agreeable. The town of Santa Barbara, like the other settlements of California, consists of a few scattered houses of adobe with tiled roofs, built without regard to regularity or comfort, filled with fleas and other vermin; the idle inhabitants loitering about or riding at full gallop through the place. It is built on a plain, about one mile distant from the shore, which here forms a slight curve. The anchorage is safe in the summer, but during the stormy seasons of the year it is very insecure. The population is about 1000. There was formerly a most flourishing missionary settlement at Santa Barbara, but here, as elsewhere in California, the power of the priests has been destroyed by the grasping hand of the government, and the missions, which brought such boundless wealth to the church, are now heaps of ruins. The summer droughts parch and burn all vegetation, and no kind of summer cultivation is successful without expensive irrigation.

The discontent among the troops having been adjusted by a court-martial, we left Santa Barbara five days after arrival, with three of the malcontents as prisoners on board, to be conveyed to Monterey, there to be put at hard labor in the chain-gang for three months.

Nothing of importance transpired until the 6th of September, when, in company with the Congress, we sailed from Monterey for the Gulf of California; the Portsmouth had preceded us by two days, and the rest of the squadron was to follow in October. On the 19th we touched at San José, and on the same day fell in with the Portsmouth; in the evening the three ships separated, our own standing up the Gulf for La Paz, where we arrived on Wednesday the 23d.

La Paz is a small settlement at the head of a fine bay of that name. It is now occupied by our troops, two companies of New York volunteers having been sent down in the Lexington. A rumor had

reached this place to the effect that Mexican troops were assembling at Mulejé, a small town opposite Guaymas, and without delay we again got underway and stood out to sea, bound up the Gulf. We sailed on the evening of Sunday the 26th, and on the following day at evening anchored at Loréto, some eighty miles below the place of our destination. Here the report was confirmed, and we were told that two hundred Mexicans had landed and were organizing a force to march upon La Paz and wrest it from our hands. The chief instigator in the insurrection is the priest attached to this last place, who has left his flock at Loréto and gone to Mulejé. To this place we hastened, and arrived September 30.

This was a memorable day in my naval career. In the afternoon I was sent on shore with a flag of truce, and was met by an officer from the town, about three miles distant; or I should say I was sent to meet him, for he was already there with a white flag. Our ship was under English colors. A few moments after I left the ship our colors were shifted and the American ensign floated gaily in the breeze. My friend with the white flag, at this sight, dashed spurs in his horse's side, and never was flight more rapid. I kept on to the beach, and finding no one there to receive me, had time to look around to see what could be done. Crossing over a neck of land, I came to the creek and took a look at a schooner at anchor there; I also directed the boat to pull around to the creek. The officer with the flag of truce was now seen at a distance slowly riding toward us, and I started to meet him. On approaching, he demanded in the name of the military commandant of Mulejé the cause of our visit. I replied that we had come to ascertain the disposition of the inhabitants. To this he said that his commandant had directed him to say that any communications with him must be protected by a flag of truce, which would be respected, but on no other occasion must our boats enter the creek, or they would be fired upon. I laughed, and answered that it would give us pleasure to be so received, but that it was a strange attitude for them to assume; we regarded the Californias as American territory, and wished to protect the inhabitants; we desired peace—had issued proclamations promising quiet and liberty, both civil and religious, to the people; the country was in our possession, and all resistance was in vain. "If you place yourselves voluntarily in arms against us," said I, "the consequences must rest with yourselves; I am coming into this creek, and if you fire upon me I will punish you." After some further conversation of little consequence

we parted, and I returned to the ship to make my report, asking permission to carry in our boats and bring out the schooner. While we were engaged in making preparations for this expedition, the officer with the white flag again made his appearance on the beach. I went to meet him the second time, and found that he had been sent by his commandant to ask if there were any reply to his communications of the morning. I told him No; his commandant had taken up arms and sent off a threat to fire upon us if we came in; that we should therefore act accordingly; his hostile message admitted of no reply; come into the creek we would. "But, Señor," said he, "we are bound to defend our country, and American jurisdiction has never extended to this place." "That is all very well," said I; "you are to be regarded either as friends or enemies; lay down your arms and we treat you as friends, but if you commit any violence we punish you." Seeing that he was disposed to have a long talk, I suspected that it was to gain time for some object the Mexicans might have in view, therefore I cut short our interview and returned to the ship to lead in the boats.

Having manned and armed all the boats, we pushed off and pulled into the creek. On boarding the schooner she was found to be deserted and scuttled, with two feet water in her hold and sinking fast. While a part of my men were landed on the beach to cover the cutting out party, others earnestly set to and plugged up the holes in her bottom, threw overboard a large portion of her ballast, bailed and lightened her, weighed her anchors, ran out warps and hauled her out of the creek. Meanwhile the Mexicans assembled in large parties on the hills, but kept at a very respectful distance. When the schooner was fairly out of the creek all our parties embarked, and as we pulled off the enemy came down gradually until they reached the beach, but offered no violence, so we carried out the prize, my first, without accident.

October 1.—In the morning I was despatched with a flag of truce to demand of the forces on shore their arms, a pledge of neutrality and non-intercourse with Mexico during the war. An officer met me; I delivered my communication for his commandant, and gave him three hours to decide. I must go back a little. On returning to the ship last night I asked the captain to give me a party to land and disarm the people. His answer was undecided, but I gained some encouragement. When I was going on shore in the morning he told me to allow them twelve hours to decide on their course. I

suggested that they had already been twenty-four hours thinking about it, as we had conferred with them yesterday. "Well," said he, "give them three hours." Having delivered my communication, I returned to the ship and we began busy preparations for a landing.

Meanwhile the captain called a council of war. Three lieutenants were assembled in the cabin, and our respective opinions asked as to the course to be adopted. I need not say we urged stringent measures for subduing the enemy and bringing him to terms. While yet in council a flag of truce was reported on the beach, and I was again despatched to meet my friend. The reply he brought was in writing, a mixture of bombast and defiance. So to arms was the order. Our boats were soon manned, and at 2 P. M., leaving the ship, I landed within the creek with eighty officers and men. My associates were Lieutenant Wm. T. Smith, Lieutenant Tansill of the Marines, Passed-Midshipman James M. Duncan, and Midshipmen Thomas T. Houston, J. R. Hamilton, and W. B. Hayes. I sent the launch up towards the town to join me there; about the same time the ship opened her batteries on the town, but it was too distant for her shot to make any impression. Having formed my men on the beach, we marched toward a hill on which a body of Mexicans had posted themselves and where we expected to have a fight. We had not proceeded far, however, when we were fired upon from a house and thickets on our left. I immediately detached a party to burn the house and drive the enemy out, while I with the rest of my force charged upon the thickets, which we passed through without encountering the unseen foe. The house was soon in a blaze, and on we marched for the hill. When we reached a height which commanded the hill, I passed an order to the following effect: "Men, we are to go to the top of that hill. If we are fired on in ascending it will break our order, as the hill is so steep. As soon as the fire of the enemy commences, let the word be, 'Every man for the top of the hill; he who reaches it first is the best man.'" The heat was excessive, and the pathway, through thorny acacia and prickly cacti, so steep that we could scarce keep our foothold; but up we went and gained the summit—the bird had flown, without awaiting our approach. I commanded a halt to rest the men, and while drawn up, with arms at rest, the enemy, in earnest, opened a fire upon us from several places of ambush; the balls whistled about us merrily, and in return we sent among them, in the bushes and behind the rocks, a shower of lead which soon started

them out up the banks of the creek. Down the hill we went to march through the town, and thus drew upon ourselves a hot fire again. The launch had now come up, and I ordered her to riddle some houses on the bank of the stream from which the enemy was firing. Our balls drove them from the bushes, and away they sped to the hilltops. Further pursuit was useless, and I commanded a homeward march for the ship. We drew off without the loss of a man and returned to the ship; two were wounded slightly, and it is supposed we killed many of the enemy, as our fire upon them was in heavy volleys. At daylight the next morning we sailed, as the weather had a threatening appearance and our anchorage was insecure; we had the prize in tow, but as it was a heavy drag upon us, towards night we fired her, and as darkness came on the burning vessel beautifully lighted up the horizon. On our way down we touched at Loréto and also at Descondido, and on Friday, October 8, again anchored at La Paz.

I had applied to the captain to give me a small schooner belonging to an American at La Paz, to man and arm her, and to let me go back to my friends at Mulejé, to cut off their communication with the opposite coast. I hoped also to catch two vessels that were said to be engaged in transporting troops and ammunition. On the evening of our arrival the captain came on board, having Colonel Burton in company; he sent for me and told me he was going to charter the Libertad, man and arm her, and send me back to Mulejé, asking how soon I would be ready. "To-morrow night," I replied. At daylight on the morning of the 9th I took charge of the schooner and began her equipment. Our 9-pounder launch gun was fitted up by a contrivance of mine to work on a pivot; this occupied nearly the whole day, but meanwhile we were getting on board provisions, water and wood. On Sunday morning I went on board with my crew of 11 men, having Midshipman J. R. Hamilton as my officer. I got underway at 10.30, but by the rapid current was swept on a bank from which I did not get off until evening. On the following night I ran into the bay of Descondido for sundry articles I wanted, and sailed again at 3 P. M. of the 12th, passing within sight of Loréto. I forgot to mention that on my previous visit to Loréto, in the Dale, I had been sent on shore to seize some pieces of artillery belonging to the Mexican Government, lest they might fall into the hands of the insurgents. I brought away three small brass guns, an old musket, and some lances.

I also heard here that the force with which we were engaged at Mulejé numbered one hundred and forty men; they had sent down a swaggering account of the fight, such as having routed us and killed six of our men.

Sunday, October 24.—Tossing about in heavy weather in my little brig, with no comfort, little rest, but leading an independent, roving life, which, added to the excitement of my cruise in the Libertad, makes it a very agreeable change from the man-of-war Dale. Since coming up here I have been prying about everywhere, and am becoming quite a terror to the small neighborhoods on the coast. In the early part of the week I made a stretch across the Gulf and looked at the barren cliffs of Mexico, hoping to meet with some adventure. I took a distant view of Guaymas, into which port I wished to run, but thought it my first duty to look again upon Mulejé, as I had been three days absent. So away I ran for its table mountains and broken crags. At daylight on Thursday morning we were off Mulejé, with light, baffling winds, but at sunrise the officer of the watch called me and reported that the wind had come out from the northwest. I ordered him to run for the mouth of the Mulejé creek. By 10 o'clock we were near enough to discover a small sloop at anchor inside; the wind had freshened so much that we had already reefed our sails. I immediately made preparations for sending in an armed party to bring out or burn the sloop. My old pilot told me it was going to blow and that it would not be safe to anchor. I was determined to get the sloop, so anchored, but it was too rough to trust my men to our miserable canoes, and, while busy in contriving an outrigger, I discovered that the sloop had taken the alarm and was warping up the creek. A neck of land covered the hull of the vessel and the men; but hoping to make them desert the vessel and give me thus more time, I commenced firing upon them with our 9-pounder, trying to cut away the spars of the sloop, but without effect. The sea was now running high and the wind increasing to a gale, and I was compelled to turn my thoughts to my own little craft. "You will have to slip, sir," said the old coast pilot, "you can't get that anchor. It's going to blow a gale, and the waters are close under our stern, sir." In fact the old fellow (the quondam skipper of the brig) was very uneasy. But I could not spare the anchor and best chain, and told him we must get the anchor, though in truth I felt very anxious when I found tackles parting and stoppers giving way and the sea

breaking over our bow; but after an hour of hard work we got the chain in short, made sail, and fortunately drove her into deeper water, where we succeeded in getting the anchor up, much to my relief, as I felt that I might need it before the gale was over. I stood out to sea, the little craft behaving very well, but the heavy sea and strong current were too much for her; we could not hold our own, and I was compelled to run off to leeward and make a port. Before night I anchored in a snug bay under the lee of Point San Juan, and there lay three nights and two days in a heavy gale.

Saturday, November 6.—The past week has been full of adventure and excitement. Having made four attempts to get in to the anchorage at Mulejé by night, all of which were unsuccessful because of the calms and light airs off the land which then prevailed, on Saturday, October 30, at 2 A. M., I hove up my anchor. I was lying about six miles from the mouth of the creek, and with a good breeze had a promise of being by 4 o'clock at the desired place, where I expected to cut out the small sloop which we had fired upon last week. But in this I was again to be disappointed; on approaching the creek we had the same calms and light baffling airs as before, and did not get to the place before seven o'clock, at which time all Mulejé was aroused and on the alert.

I now became rather desperate, and finding it impossible to get upon the people by surprise, resolved to carry my plans into execution under their noses. So I landed Mr. Hamilton with eight men to reconnoitre, at the same time anchoring the brig within eighty yards of the beach. A description of the place is necessary to enable one to better understand the localities and the difficulties to be encountered. The village is on both sides of a creek running through a pretty and fertile valley; the waters of the creek are too shoal to admit my vessel, which is therefore compelled to lie outside at a distance of about one mile and a half from the town, for it is that far from the mouth of the creek, and the sloop I wanted to get at was fully two miles from me. Could I have sent on shore twenty men they should have gone in broad day, but as my crew is only thirteen all told, and as I must have some remain to work the gun and take care of the vessel, I resolved to land a party at midnight or towards morning, to bring out or destroy the sloop. Mr. Hamilton and his party having made the necessary observations, came off to the vessel.

No sooner had he left the beach than the Mexicans began to assemble, having kept at a respectful distance while he was on shore.

They offered no violence, however, but one fellow, bolder than the rest, stood on the hill, and throwing up his hat shouted, "Aha, Americanos, muy malditos!" His further cursings were cut short by a musket ball which was sent after him by way of cautioning him to keep quiet.

During the day we were undisturbed at our anchorage. Everything was prepared for a fight, and after dark I hauled the brig in still closer to the shore that I might the better be able to cover the cutting out party. But a watchful Providence, whose guidance I had asked, prevented my sending in the men, for whom I had asked His protection. At about 9 in the evening I discovered that there was a sentry posted close by the vessel. I saw him striking a light for his cigar, and thus was warned that the people were under arms, being alarmed by the Americans lying so close to them. I directed one of my men to fire on the sentry aforesaid so quietly lighting his pipe, by way of letting him know he was discovered. I suppose he was not struck, but knowing that their watch was observed, the Mexicans now passed the call "Alerto," and I could count it from man to man until lost in the distance. We all were under arms, and most of my men lying down, as I resolved, if nothing further turned up, to land my party at all events and try to pass these sentinels. I loaded my double-barreled gun with ball, and threw myself on my bed on deck with my gun by my side, waiting for the small hours of morning, thinking the people would still be surprised by the boldness of the stroke meditated.

I heard no sound ashore, but the passing of the sentry's call, till about half-past ten o'clock, when bang! bang! bang! they commenced from every direction. I jumped out of my bed, seized my gun and fired at the group nearest me, which I could only discern by the flashes of the guns. My men were under arms in a moment, as everything was fortunately prepared. I directed them to fire at the flashes and waste no shot. The pivot gun was soon in operation too, and fired upon such points as seemed to be occupied by the largest groups of the enemy. The moon was rising behind us, so these Mexicans had us as a target against the sky, and kept up a pretty good hail of balls whistling about our heads for about half an hour; but so well did my crew obey my orders to watch and fire only at the flashes (we could in no other way ascertain the position of our assailants, who were constantly changing their stations)—so well, I say, was our fire directed, that in half an hour we drove them from the beach; their fire

slackened, and by half-past twelve all was again quiet. No one on board was hurt, but I decided not to risk my small party by sending on shore that night.

The next morning a boat was reported coming in from seaward. Our canoe was despatched and the brig gotten underway in five minutes, and at noon the prize was brought alongside—a poor, scared beggar, named Juan Battista, who said he was no Mexican, but an innocent sealer, and a native of Italy, that he had been absent from Mulejé three weeks, and had had nothing to do with the war. Hoping to extort from him some information, I ordered his seal skins and goods to be passed on board and his canoe hoisted in. This alarmed him, and I could not suppress feelings of pity for a poor fellow caught thus in sight of his home, where he perhaps had wife and children watching his little boat çoming in and witnessing his capture. But I would not let him go, telling him that I regarded him as an enemy, and that I would keep him and give him up to the commandant at La Paz. Finding myself very short of water, I at night kept away to the southward for Loréto (the nearest good water), and now my prisoner began to wake up; he thought surely enough I was going to La Paz. From him I learned that the forces with whom I was engaged on the 1st numbered about 100, and that none were killed; this last I did not believe. On Monday afternoon my captive could no longer restrain himself. I notified him that if he gave me the information I required I would restore his property and give him his liberty, otherwise he would forfeit both; so before the sun was set on Monday he let me know that he had charge of the sloop owned by Mejia, who got up this revolt. Little by little he gave me all the information I desired respecting her whereabouts; so threatening him with some dire punishment if he were deceiving me, I tacked and stood to the northward, putting the crew on an allowance of three quarts of water per day. On Tuesday evening we again passed Mulejé bay, and keeping on about twenty-five miles, the next morning at sunrise discovered the prize we sought. The townspeople had already taken the alarm and sent a body of horsemen to protect the vessel, I suppose; but I very quickly dispersed them with a few rounds from our pivot gun, and they soon scattered to the hills, while our canoes brought out the prize, a pretty little sloop of twenty tons with everything in fine order. The crew abandoned her and swam ashore as our boats pulled in. Off we went for Mulejé to display the Alerta, for such was the name of the prize, and I have no doubt we were

cursed enough when we made our appearance there on Thursday morning.

My cruise in the Libertad continued until the 19th November without further incident. On that day I arrived and anchored at Guaymas, having received orders to proceed there. On my arrival I found myself just too late for the fight, to explain which I must give a sketch of the proceedings at this place. Late in October the Congress and Portsmouth came to Guaymas, and after delaying twenty-four hours, demanded the surrender of the place, giving five hours for a reply; this was at 1 P. M. No reply was given, and ere the time allowed had expired, night and darkness came on. With the morning light the two ships opened their heavy batteries upon the walls of a deserted town; the troops had withdrawn during the night, carrying the few guns from the fort, and the inhabitants, who were prevented from surrendering through fear of their own troops, had abandoned their homes.

The cannonade was continued for nearly two hours, and the unresisting, unoffending houses suffered considerably. The ships then ceased firing and sent a party on shore to take possession of the empty place, and a proclamation was read. Captain Lavallette made appointments of military commandant, collectors of revenue, and other dignitaries, and sailed, having withdrawn the garrison, and left the sloop Portsmouth anchored off the town. A small rocky islet, about one mile from the town, was chosen as a suitable place for hoisting the American colors; and there they wave, safely removed from danger.

Early in November the Dale arrived to relieve the Portsmouth, expecting to find Guaymas a very respectable place and quite Americanized. The Portsmouth sailed, and the little Dale remained sole monarch of the town and harbor. A new proclamation was to be read to the inhabitants (who had not yet returned, by-the-bye), informing them of the great happiness they would enjoy while under the protection of the American arms, and the pecuniary advantages to be realized by the reduction of duties. Before reading the proclamation, the captain of the Dale, on the 17th November, landed with seventy men; and when approaching the Plaza, was received with a volley from a window, by which he was shot through the foot. Lieutenant Smith (the next in command) then formed the men to fight his way back to the boats. Every house breathed fire from its doors and windows, and the officers thought that the whole party were

doomed to destruction; but the men were so well disposed by Smith (who took up three positions commanding the Plaza), and their fire was so heavily poured in upon the Mexicans, who were sallying from the houses and forming, that the enemy was thrown into the utmost confusion and a flight commenced, about 400 Mexican soldiers being routed by about seventy seamen. Smith and his gallant associates had the satisfaction of seeing themselves left masters of the place. When they were attacked they fought in order to make good their retreat; but so doggedly did they stand and fight more than five times their number, that the foe was panic-stricken. The streets were filled with killed and wounded Mexicans, while of our party none were injured but the captain.

In this affair Lieutenant Tansill commanded the marines, and led that gallant little band into the thickest and hottest part of the fight. Passed-Midshipman Duncan had my company, and all behaved with most admirable coolness and a steady courage which alone turned the scale in their favor.

January 21, 1848.—Since my last date many weary and uninteresting weeks have passed at Guaymas. Toward the end of December the Southampton came in to relieve us for a while, that our ship might go to some place for water; and about the same time I, too, had some little excitement in the capture of a small schooner. I left the ship one day in the launch in search of adventure, and made an excursion to the bay on which the Mexican forces were encamped, about 12 miles from the ship by sea. I pulled in quite close to the beach and threw a few shot ashore among the soldiers, by way of rousing them from their siesta; after which, while coasting along the shores, I discovered a small party, sent out evidently to watch for and get a chance at me, skulking among the bushes. I quickly gave chase and drove them back to their camp. Evening was drawing on and I was on my return to the ship, when, just as the sun was going down, we discovered about three miles from us a schooner running in for the bay. We were about equally distant from the entrance of the creek, and at once a most exciting chase began as to who should reach that point first. We succeeded in cutting her off and I opened fire upon her, as I found they were bent upon running her on shore, and this they succeeded in accomplishing. Night and darkness had come on, but we could not lose our prize, though every moment expecting an attack, as the camp was only about a half mile off. Duncan, who was with me, jumped overboard when we were as

near the beach as we could safely go, and with three men swam to the prize, carrying a tow-line, and we soon carried her out in triumph. She was laden with a valuable and most acceptable cargo of good things in abundance, cheese, figs, raisins, dates, sugar, etc., with all of which we got back to the ship at about 8 P. M.

We left Guaymas December 23, and anchored in the bay of La Paz on Christmas day. A busy week was spent in La Paz, and our ship again made ready for sea ere the New Year was ushered in. At length we sailed for Mazatlan, where we arrived January 6, and remained two days. Mazatlan is the first civilized place we have visited since leaving Lima, and it is a pretty and well built town, with well-filled shops, inviting restaurants, good markets, and beautiful gardens. The town is in possession of our squadron, the Independence and Congress lying here, and having the greater portion of their crews in garrison on shore. Business goes on as usual and everything seems lively and gay.

We sailed on the 8th and ran over to San José where we hoped to meet with the Portsmouth, but to our great disappointment found she had a week before sailed for home. The little town of San José is in possession of the squadron, being garrisoned by a force of 50 seamen and marines in charge of Lieutenant Chas. Heywood. A few weeks before our visit this garrison, at that time only 25 men, was attacked by a body of 150 Californians, who boldly advanced to the assault of the building in which Heywood was posted; but in the onset their leader was killed, and with considerable loss they were repulsed, though a skirmishing fight was kept up for several days. I should not omit speaking of La Paz too, for we found that place nearly reduced to ruins; "grim-visaged war" had visited that pretty village soon after the Dale left. The Californians, in force about 400 men, attacked Colonel Burton's force of 110 New York volunteers posted in two large buildings and the church, and continued a kind of skirmishing siege for about eight or ten days. After losing about sixty of their number the assailants withdrew, but not until they had brought in the brand to assist in desolating the scene. All of that part of the town not protected by the garrison's muskets was burned.

February 1.—Again at Guaymas. We arrived here four or five days since and relieved the Southampton, in which vessel our late commander took passage to Mazatlan. Soon after our arrival we heard that the general in command on shore had sent a company of troops down to garrison the village of Cochori to cut off the supplies

of fresh provisions we had been receiving from that place, and perchance to capture some of our boats; so we made up a "tea party" for the occasion.

On Sunday morn, January 30, I left the ship in command of an expedition to surprise and take this garrison. We went about four miles in our boats, and landing through the surf on the beach some three miles from the village, with quick step and profound silence marched upon the place. On getting near the village I detached the marines, twelve in number, with orders to get near the outpost and lie concealed until I had reached the barracks, that our assault might be made simultaneously. Lieut. Fabius Stanly led the advance, and we pushed on through thicket and hedge until within 100 yards of the barracks undiscovered. We now divided into two parties, Stanly leading to the right, I filing to the left, that we might surround the barracks before assaulting it As my company were filing around the corner of the barracks we were discovered and fired at by the sentry on the house. Stanly had reached the front of the barracks, surprising the sentry there and seizing him with his own hands, not, however, until he had given the alarm. In an instant a number of the guard rushed out from the rear and fired in the faces of my men. I ordered a charge, but as it was pitchy dark some escaped, while others were shot down while flying. As soon as we fired I had the satisfaction of hearing a volley from the marines, who rushed upon the picket guard and overpowered it. Lights were struck and we found we had captured Captain Mendoza and his lieutenant with their mistresses, all in charming *déshabille;* the fair ones, thus by the rude "larums" of war roused from their repose, seemed in nowise agitated, but *au contraire* very interesting indeed. We captured, I say, the captain, lieutenant and eleven privates; in the assault five were killed and two wounded. Twenty stands of arms, 500 rounds of ball cartridges, a stand of colors, and a quantity of provisions also fell into our hands, as well as the guard boat.

Day was now beginning to dawn, and bidding my officer prisoners to put on their clothes, I marshaled my forces and marched them to the beach with all of our spoils, leaving Stanly with a guard to make a more thorough overhaul of the barracks by daylight. I made signal for the boats to come in, and at about 7 A. M. commenced embarking my men. When all were off, I took the officers into my own boat and made my return in triumph to the ship. The captain was very much depressed, but the lieutenant seemed quite delighted

with the idea of not being numbered among the dead. My breakfast was already prepared, and at 10.30 I sat down and entertained my unfortunate guests, giving them stewed oysters, omelette, toast, and hot coffee. So much for the affair of Cochori. The friendly Indians immediately reopened their trade with us and we now get along quite comfortably. A sad business this matter of war! Some hearts were widowed to-day; some were made fatherless. May the God of battles have mercy on those who fell in this their country's cause! Among those killed was a sergeant, in whose cartridge box were found, carefully preserved, several letters from his wife, telling of the health of the children, of her affection, and desire to see him return from the war. She is sixty leagues from here and in a few days will receive the sad news of her loss.

April 3.—For a long time I have written nothing, as there have been no events of importance to note; true, there have been some trifling skirmishes between small parties of our men and the various outposts of the enemy, but nothing serious, and the loneliness of our situation may be imagined when the arrival of a small sloop, navigated by two or three men, would afford us quite an excitement and sufficient food for a day's talk. But to-day our long looked-for commodore arrived, after a journey from home by sea and land of nine months. We are right glad to see him and to receive the letters which arrived, some having unfortunately been lost by the wrecking of the vessel in which the commodore was coming down the bay of Monterey.

The month of April passed away tranquilly. We heard of the armistice and that the war was wellnigh at a close. I most truly wish that it may really be over, for it cannot but be considered an inglorious war for our navy, though brilliant the laurels won by our gallant army. This war has brought to my mind a confirmation of the opinion I have long entertained with regard to the efficiency of the Navy. *Efficiency*, do I say? *Inefficiency* is the term I would use; for most wretchedly inefficient is our Navy, once the pride of our country. How it has fallen within the past thirty years!—during a period when all the civilized world has made such strides in improvement; when the world, blest with a long peace, has turned its attention to arts and sciences, and all the great privileges which can alone be enjoyed in peaceful times, while at the same time the great nations have not been unmindful that peace is preserved only by being prepared for war.

Of all our commanding officers, of whom there have been *five!* on this station during the past two years, Commodore Stockton has been the only one who has come up to my ideas of a naval commander. His conduct has been characterized by promptness, decision, unusual bravery, and boldness of purpose. He has fearlessly discharged the duties of his station without any selfish consideration of personal responsibility, which, alas! is but too frequently the first and only thing by which many of our officers are actuated. From the commencement of the war Commodore Stockton turned his whole attention to the conquest of the Mexicans, and to ensure success in the accomplishment of his purpose, the whole disposable force of the squadron was employed. The squadron, insufficient as it was in numerical strength, was reduced still more so by the negligence of the Equipment Bureau, the men not being half fed and greatly in want of proper clothing. But, notwithstanding all the obstacles he had to contend with and the method of warfare to be adopted by seamen, he figured conspicuously, marching into the heart of the country, declaring his purpose, and with the seamen of the squadron brought the Californias under subjection. You must not suppose me a sworn Stockton man, for I am by no means an admirer of his; he has his weak points, perhaps more than most men, but at the same time he has, by comparison, thrown all of his compeers in the shade, and indeed as an officer I do admire him. He was succeeded by Biddle, who was in his youth a gallant man, and I therefore will pass him over; his infirmities and age* have long since unfitted him for command, and his natural acerbity of disposition causes him to look upon all men with a degree of suspicion. Then came Commodore Shubrick, who after some time applied for leave and was relieved by Commodore T. Ap C. Jones. Who so blind as not to perceive the disastrously disorganizing effects of these frequent changes in the command of a squadron in time of war?

But I will forbear to speak, and pass on to the armistice and its consequences to this place. We, to whom the pleasures have so long been forbidden, may now indulge in a visit to the uninteresting, uninviting town and vicinity. The people, profiting by the temporary cessation of hostilities, are glad to avail themselves of the better shelter of their town houses, and abandoning the huts which had been constructed for their convenience in the neighboring villages, came quickly back to the town, where, protected by our men, they enjoy

* He was 65 years old and died shortly after, October 1848.—ED.

more liberty of conscience, freedom of action, and security of property than they have ever before known. The shops are re-opened, houses injured by shot repaired, and in a few days the place in everything resumed its former appearance. When I speak of injury done by shot you may think of any number of houses knocked down and imagine all sorts of ruinous injury, but such is not the case. The houses in this country and California, and indeed in most of the towns of Spanish America, are built of adobes, or sun-dried bricks, the walls are commonly about two and a half feet thick, and the greater part of the houses are of but one story in height. These adobe walls when dried by the parching winds of this climate become one mass of brick, one solid brick, so that a cannon shot striking the walls, though it may perchance strike where the corner stone of our houses is placed, merely makes a clean hole and brings down none of the superincumbent wall. The most severe injury inflicted on the people of Guaymas has been by their own countrymen and defenders, by whom the houses have been broken open and pillaged of all movable property and the furniture wantonly destroyed.

One of the first persons I met with on visiting the shore was my old midnight friend—and prisoner—Lieutenant Zaavedra, whom I found installed at the billiard rooms, which are kept by him—a kind of public house, by the way, where liquors of every variety and excellent quality are served up, and where wretched beefsteak and garlic, with a tolerably good omelette, are also served up to the hungry wayfarer. My friend Zaavedra—Don Juan, as we style him—was vastly delighted at seeing me, and, extending to me the hospitalities of Guaymas, in the excess of his pleasure took me to his house. He then entered into a long recapitulation of his sorrows during the war, and I believe he looked upon me as a benefactor, as in capturing him he became released (by parole) from further service; at all events he implied as much, as he unreservedly told me he was very glad indeed to get rid of a service that brought him neither honor nor pay. There was none of the former issued to the Mexicans in this war, and the latter was all appropriated by those highest in rank. He also complained bitterly of the losses he had sustained by the troops, who had not spared his billiard room and its equipments—his liquors they had entirely carried off, from his safely locked store—and the cloth of the tables had been converted into trowsers; however, with a degree of elasticity and good humor quite worthy of a Frenchman, my friend laughed it all off and said his uniform was now for sale.

The people of this part of Mexico are generally of a low class; there is no rascality unknown to the men, and laxity of morals among the females is thought of little consequence, and therefore you find that in three or four families out of five the mother is only a mistress. The women are not pretty by any means, and decay at a very early age. It is not uncommon to see a girl of fourteen a mother; consequently the woman of twenty-five appears ten or twelve years beyond that age. This very early marriage is alike destructive of the constitution and morals. There is but little regard paid to common decency, though they do preserve a semblance of modesty; but their extravagance in dress surpasses all bounds in both sexes. You will see the washerwoman after a day of hard toil turn out on the holiday with a rich silk dress (let me say here that the prices are about treble the cost of such articles in New York) and pearls, with a fine *rebozo*, silk stockings, and embroidered slippers; and you will see a muleteer with a shirt, the only one he possesses, of the finest cambric, its bosom and collar richly embroidered, fine linen drawers, and velvet trowsers decorated with gilded buttons by the gross, and this suit is kept on until it falls to pieces. I have been told that these men pay frequently $30 and $40 for one shirt, and the rest of their suit is in the same proportion of expense. Alas for the pride of the Spanish race, a man decorating himself while starving!

I believe I have not said anything about the bay and town of Guaymas, and may as well devote a part of this page to that purpose. The bay is very capacious and of sufficient depth for vessels of the largest class, though the water is shoal near the town. When in the bay the view is on every side bounded by rugged and barren hills, on whose sides there is not a solitary spot of green, though there is a sickly little bush with very minute leaves, and the cactus grows to a giant size in the parched and thirsty soil. I have seen its stalks shooting up twenty feet and more, and nearly two feet in diameter. Some of its varieties bear a rather agreeable fruit, which in the autumn constitutes a large portion of the food of the poorer classes. There is no agreeable vegetation, no groves of trees upon which the eye may rest—all is barrenness. The town consists of but three streets, running parallel with the shores, and its population is about twenty-five hundred. The houses are of adobes, one lofty story in height; a style of building admirably adapted to the country, for the very thick walls most effectually exclude the heat, which is here intense. The roofs are covered to a depth of eighteen inches with

clay; these, with the brick floors, make the houses very comfortable. At night the people sleep in the open air; those who have a court-yard within their walls spread their mats there, and those who have no such place of privacy spread theirs before the doors in the streets, men and women, in very primitive style. In the immediate rear of the town the hills rise nearly perpendicularly to the height of nearly two thousand feet, and seem, with their "horrid crags," to overhang and threaten the place.

The captain, purser and myself made a party for an excursion to San José, or Rancho, as it is most commonly called. An American gentleman of the place provided us with a carriage, two mules and muleteer; he too accompanied us, and off we started on one of the hottest days of June. Our road ran through a valley perfectly level the whole way, but all was barren and burnt up, and I am told that such is the character of the country throughout its whole extent for hundreds of miles. At the Rancho, which is merely a small village of adobes, we were very civilly received by the authorities and some of the "upper ten thousand" whom we visited, and in the cool of the day returned again to Guaymas, without having seen or learned anything worthy of remembrance.

Soon after the armistice we were visited by a portion of the Maricopas, a tribe of Indians from the river Gila. They came, so said their chief, to see the Americans of the United States, hearing that their country was to be taken possession of by them; they came to let us know that they were always our friends and were glad to come under our rule. They were nearly naked; the most conspicuous article of dress was that worn by their chief, in the way of a nose ring. A huge silver ring with a plate nearly as large as a quarter of a dollar was stuck in his nose, and being an ornament designating rank and high birth, he seemed quite possessed with a sense of his own importance; but, without jesting, this rude son of the forest had more of the natural dignity of rank than you commonly find among the better dressed civilized races. He spoke Spanish tolerably well, and seemed full of life and spirits. The style of dressing their huge shocks of hair being peculiar I will mention it, as it may some time be adopted by our fashionables. The women had their hair thickly plastered with mud; whether to keep their heads cool or to destroy vermin I know not, but they appeared to think it very fine. Our captain invited them to visit the ship, and they accepted the offer with so much avidity we supposed them different from the Indian

race, thinking they were moved by curiosity. But not so; the usual apathy of the red man was never more conspicuous; they expressed no astonishment whatever, though they had never before seen a vessel of any kind. We asked them if they had ever heard a large gun fired? "No." Well, a large gun was cleared away, and being directed over a range of waters, fired. Still there was no astonishment other than was expressed in the "ugh"; but about a mile and a half from the ship the shot struck the water and commenced skipping along, then indeed they forgot themselves and gave a shout of admiration and wonder. That a ball nearly as large as a man's head should be thrown such a distance was beyond their comprehension, and at every graze, as a volume of water was sent up high into the air, there was a fresh shout. This was the only thing that pleased the Indian.

In June a vessel arrived bringing letters; and in June, too, we suffered from the scorching north winds. How hot they are! how insufferable! No hot blast from a furnace can be more parching; the air, at all times excessively dry here, is beyond endurance when the north wind of summer comes rushing along over these sun-burnt hills of Sonora. In the latter part of this month of June more letters were received, and I got several that came overland, one of them but seven weeks from home.

In the last week of June the Ohio and Congress arrived at Guaymas, causing quite a sensation, enlivening not only us, for the whole country for miles around seemed to be aroused by such an event. No ship-of-the-line had ever before visited Guaymas; so not only did the people of this place crowd on board, but many families came from a distance of one hundred and fifty miles to see the Ohio, and all were delighted with the magnificent ship. Her coming was the occasion of considerable festivity, too; dinners and dances were quite the order of the day. We had just received news that peace was concluded, and this was additional cause for rejoicing.

July 1.—The Dale evacuated Guaymas, hauling down our national colors under a salute of twenty-one guns.

July 4.—The day was celebrated on board the Ohio in a manner not soon to be forgotten, I presume, by those concerned. The Commodore gave a collation at 1 P. M., and in the evening a *tertulia* was given on board our ship, when the beauty of Guaymas assembled, if it may be called beauty. However, there were two or three very good-looking women from the interior; they danced and waltzed

gracefully, and with the fine band from the Ohio we made a very pleasant night of it. An Indian ballet was danced by a bride; the dance was unmeaning and ungraceful, and the music a few simple notes, but the woman was pretty, and the chief charm of the dance was in the timbals worn on the knees and with which she beat time to the music.

July 5.—On this day we took our departure from the detested bay of Guaymas, and in company with the Ohio and Congress sailed for La Paz, where we arrived on the fourth day out. Lower California for some unaccountable reason has been given back to Mexico, and consequently there is great distress among those of the inhabitants who, during the war, have compromised themselves by their adherence to the Americans. It must not be forgotten that, by the proclamation of our naval and military commanders, *the whole* of California was declared to be annexed to the United States; this was done not only by authority, but, under instructions from the Government, protection was promised to the inhabitants, and their property and rights guaranteed to them. A force was also sent to occupy and garrison some of the principal ports, and things thus went on quietly for a few months; but the spirit of insurrection, which had been crushed in Upper California, was by some designing men revived here, where they hoped by an overwhelming force to reconquer the territory and thus make themselves "buen merito" of their country. When the insurgents took up arms other proclamations were issued, enjoining all peaceably disposed people to remain at their houses, protection was again guaranteed to those friendly to the Americans, and there being quite a party so disposed, they naturally availed themselves of the assurances held out, espoused the cause of the United States, to which they wished to be annexed. But after all of these proclamations and promises these unfortunate people have been betrayed, their territory passes back to Mexican domination, and many of them are threatened, not only with the confiscation of property, but with death. So we find our old friends of La Paz in great trouble, for all of the best portion of the inhabitants had taken up arms in support of our flag.

After a delay of three or four days only at La Paz, our ship, being of convenient size for despatch, was sent over to Mazatlan for mails. The country about Mazatlan, watered by the showers that are now so frequently falling in these latitudes, is quite green, and it is really refreshing to see a landscape with its green hills and fruitful vales,

and then, too, to get some of the fruit. After our long banishment to such out-of-the-way places as Guaymas, Mazatlan seemed quite like a city; and indeed it was high time for us to get to a place where our many little wants could be gratified, and I had quite a busy day on shore shopping. It was so long since I had been into a respectable store, I could not help going about and looking at the many pretty things to be seen here.

We found the Mexicans in the midst of a fresh insurrection. No sooner is their war with us over than they recommence their own fights; the whole country is in a state of disorganization, and I don't know when the wretched people will have any quiet and orderly government. They are certainly not at all qualified for self-government, being too ignorant and too easily deceived by their military leaders, who are their rulers. The various chieftains are always struggling for their own aggrandizement, and there can be no quiet, no law, no security in Mexico while such things exist as are at present permitted.

After four days spent at Mazatlan we again sailed for La Paz, where we arrived on the 27th of July, and are quite pleased again to be in a snug harbor where we can have such luxuries as milk in our coffee, and fine figs and grapes.

Sunday, August 27.—The weather is very hot to-day, and we are bound in for Mazatlan, where I hope to find letters from home. I believe I have elsewhere made mention of the fact of my reading prayers on Sunday to the ship's crew; I have been in the habit of doing so for several months past by the captain's request, and I have used the prayers of the morning service. This morning I read the Litany—that most solemn and beautiful portion of the Liturgy.

September 26.—The month of September has nearly gone and will soon be recorded in the past. It is some weeks since I have written anything, though agreeable events have taken place—most agreeable changes in our cruise, brought about, as it were, accidentally. On our return from Mazatlan to La Paz, where we arrived on the 7th of this month, we found none of the squadron; all had left, and the troops which were to have gone up by land had also gone away in the ships. This was to us a most unexpected event, and as matters have turned out we are delighted. The commodore probably expected to meet us at sea, for he left no instructions whatever, whether we should follow, or carry out the designs which he had verbally communicated to our captain; therefore it was at once resolved to water ship, go to Mazatlan, and if no orders were received, to pro-

ceed to the Cape, with the expectation of finding there some news for our guidance. While we were lying at La Paz we had, on the 25th, a furious hurricane which was, fortunately, of short duration, for in its violence it destroyed nearly one half the town. Our ship having been made snug did not suffer, but from this rough specimen we are able to form a pretty correct idea of the autumnal gales of this quarter of the world

We sailed from La Paz on the 14th, touched at Mazatlan on the 18th, and in the evening we filled away for Cape St. Lucas. Before reaching that place, however, a change came over the spirit of our captain's dreams, for on the 21st, the cape in sight, the weather assumed a most threatening aspect, and all things seeming to portend a gale such as we had experienced at La Paz, the wind beginning to blow right wildly from the southeast (the worst quarter here), it was at last decided by him that the most proper course to pursue was to follow the commodore. This was the point we had been trying to attain, and right glad was I when in my watch the order was received to "keep away." A solid year spent in the Gulf of California was thus put an end to, and our fears that we should still be detained two months longer were thus extinguished, so on the 21st of September we bade adieu, I hope a long adieu, to Lower California. But the sea of Cortez did not seem disposed to relinquish its claims so easily; for three days we were buffeted and tossed about in its parting gales; a most unusual wind from the southwest coming in and seeming to dispute our exit; but good weather has come again, and we now look for our arrival at Monterey to see what will turn up next.

November 11.—*Monterey. U. S. S. Warren.* Yes; I have with a vengeance seen what was next to turn up. We arrived at Monterey on the 15th October and found the Ohio at anchor, a few days ahead of us only. On the 19th the commodore sent on board of the Dale a special order in relation to the discipline of the squadron, by one part of which watch officers were not to be allowed to go on shore. I may here observe that the temptation held forth by the easily procured gold at the "placers" was irresistible and the desertions from the Ohio were without limit.* In a moment of vexation the above capricious order was issued; it is sufficiently evident that such an order was by no means calculated to prevent desertion, for the opportunities to desert were not at all lessened, as the intercourse with the shore was the same as before, the boats constantly plying at

*The Dale did not lose a man by desertion while on the station.—ED.

their usual hours with "idlers" (those who do not keep watch) on liberty.

The injustice of the order was so apparent, and it was so directly at variance with usage and law, that I, for one, could not but look upon it as an outrage; so I sat down at once and addressed a letter to the commodore requesting him to reconsider his order, that it might be withdrawn or made *general* in its operation. Many others felt as I did but did not care to run against the pricks; two lieutenants of the Ohio did make verbal remonstrance. The day after my communication was forwarded a confidential communication was addressed to us three complainants, which document was so carefully worded, and its special pleadings so artfully woven, that it was evidently intended as a net behind which the commodore should partially screen himself and in which he might catch the unwary. I thought it unsafe, therefore, to enter into a correspondence on the subject, being determined to "bide my time" and make my complaints at home.

A day or two after the confidential address appeared the restriction was removed, or rather deprived of its obnoxious points, though the liberty was not so great as was desirable, yet none could complain. I was at this time sitting as a member of a court-martial, which adjourned on the 31st of October. On the evening of that day I received, through Commander John Rudd,* an indirect and confidential bit of advice, to wit, that I had better recall my letter or explain it away. I immediately replied I would do neither; that as for withdrawing it, I saw no necessity for so doing; it was true the restrictions had been removed, but I had written it previously to their removal, at a time when I considered myself aggrieved, and as for explaining, or in other words, apologizing or saying I did not mean what I said, I would not be guilty of such a folly. I meant all I said and would submit the matter to any tribunal. I would never withdraw what I had said. The conversation on the matter was ended by Rudd's saying, "I give you this advice as a friend, lest any trouble or future difficulty should grow out of that letter." I thanked him for his kindly feelings and assured him I had acted from a sense of duty; that as for any trouble or difficulty, I apprehended none; there was nothing in my letter which could be considered exceptionable, and although I would not wish to be brought before a court on any pretext, I did wish to see matters of this kind tested, and I should

* Commanding the Dale.—Ed.

stand upon my rights. The Dale was to sail on the following day on a short cruise, after which she was to go home. The Dale was, however, delayed until the next morning after, but while eating my dinner (Nov. 1) a peremptory order was brought transferring me to the Warren. Somehow or other I had had a presentiment of some such thing, and therefore my mind was in a degree prepared for it.

I left the good ship Dale on the morning of 2d November. I felt like leaving a home; many of the men wanted to go with me and share my fate whatever it might be. I considered this as the most flattering evidence of the good will of sailors; but even this proof of their regard and respect did not prepare me for what took place. As I shoved off from the ship, the crew, seeing me leaving, had with one consent gathered on the forecastle, and as I left they gave me three such hearty cheers as would gratify any public man who sought popularity. The feelings which were aroused within me were those of gratification indeed and surprise, for I had not sought popularity, and had only tried to do my duty. I knew indeed that the crew had confidence in me as an officer, but I knew not that their good will was so general. I almost shed a tear at this honest token of Jack's affection; and I felt, too, that the commodore had unwittingly made me an object of honor.

On board of the Warren I find myself quite contented and comfortable. The old ship is pretty much of a wreck, but we have a very agreeable mess, and I am resolved to be contented.

January 28, 1849.—I have in general committed to my pages here only such matters as may be agreeable and instructive; this last word seems out of place, as who should find instruction in anything relating to California customs and the usages of California society? But say what they may who have croaked over this country, ridicule has now turned to wonder, and the croakers, the scoffers, the *loafers* are all crowding to California. Such is the power of gold over the minds of men, that places hitherto looked upon as uninhabitable, dreary tracts of waste avoided by the beasts of the field, mountains with their cragged sides and tumbling torrents, are now the goal for which all rush with an eagerness more deplorable than can be imagined. Covetousness, with its attendant vices, never had so fair a field of action since the world began; gold is the first thought of the dawning day, the last thought of the twinkling twilight, and aye the glittering metal still hangs about us in our dreams, gilding all we touch, and many the bright, airy fabric raised in our fancies during slumber.

But slumber and the dead hours of night are favorable, too, for the designs of those upon whom the dread sin has wrought, or developed the vice in its most terrible shapes. Murder and robbery stalk about in the midnight darkness, and amid the cries of the coyote may oft be heard the screams and cries of the victim who for his gold is sacrificed.

On the night of November 14 a number of men belonging to this ship, having gained the faithless sentry, lowered a boat which had been hoisted under the bow for painting and repairs. The officer of the deck heard some noise and his quick ear detected some foul play, so seizing a musket and calling to the corporal of the guard, he ran forward in order to stop a portion of the crowd who were rushing for the boat; for the movement was evidently well arranged and had many participants. Six men had already leaped into the boat, and among them the sentry by whose baseness the plot was permitted. Finding themselves discovered the mutineers pushed off; the officer ordered them back or he would fire into them. "Fire and be damned!" was the reply, with a threat also of firing back, for the sentry had carried his musket. The officer fired and ordered the corporal to do so. Three shots were quickly fired into the boat, though it was too dark to distinguish anything save the one object on the water moving rapidly away. Meanwhile a boat was lowered and an exciting chase commenced; the distance to the beach was short, and the pursuing boat reached there a few moments after the pursued. The deserters had all escaped save one, and that one the treacherous sentry; one musket ball had singled him as its victim, and he lay groaning in the boat with a ghastly wound. His leg from the hip to the knee was laid open to the bone, the ball having then passed through the leg below the knee, shattering the bone. Thus was he, who but a half hour before paced on his post in the full vigor of manhood and health, now brought back to the ship a criminal, dreadfully wounded and crippled for life, a life of suffering and disgrace. That musket ball was well directed, and conveys a moral to every one placed in a situation of trust, to every one whose sworn duty it is to guard and protect his country's honor and interests.

But let us follow those who succeeded in effecting their escape. Three seamen, Wm. Banbury, Peter Reamer, and Peter Quinn, with two marines, safely reached the shore; one, as we afterwards learned, had a bullet through his cap. These five miscreants are bound to the gold regions, and already fancy themselves among the successful

miners; visions of wealth are already dancing before them, and they hurry on, rejoicing in the brighter days in anticipation. Do they know they have three hundred miles to travel? Do they know that their journey is over mountain path and desert wastes? Do they know that the settlements are but remotely situated on their road, and that no friendly hand will give them bread or meat or shelter? Food is too dear; flour is at one dollar per pound where the gold is plenty, and as for shelter, men do not now trust strangers willingly; too many deeds of violence are committed, and those who have houses like not to entertain unknown travellers, on foot, too, and without money. But on they journey; they must not tarry, for they are pursued, and they must be quick and wary or they will be caught; so they diverge a little from the road, and after a walk of some fifty miles reach a place called Soledad. Here they meet two other fugitives flying from the very region to which they are hastening, two scoundrels named "Mike" and "Lynch," who a few days before, having begged shelter and food at the camp of two miners, had during the night most brutally murdered their hospitable entertainers and robbed them of their gold. The alarm is given, the avenger is following, and on horses stolen they fly for life. At Soledad they meet the five deserters, a choice gang are they, and the hand of fellowship is crossed.

The marines, however, fortunately for themselves, seemed to have tired of their partners and at this place dissolved company. The murderers represented to the seamen that mining was at this wintry season impracticable, and proposed striking to the south, where more genial climes were found, and wine and women with their sunny smile all invited to the south for the winter. "We have," said they, "money in plenty and will share with you; at the first rancho, too, we will buy you horses." The willing sailors not needing much persuasion, joined the two whose hands were already dyed in blood, and the five set out for the south. At the first rancho they stole three horses, and thus all are mounted, though the sailors are but badly off for equipments. In a day or two they reach the friendly roof of an Irishman named Read, who with his native family occupied the deserted missionary establishment of San Miguel. This man invites them in and good substantial food is placed before them, a cheering fire blazes on the hearth, and there they rest their wearied limbs, passing the evening in tales of wondrous import, the fanciful mind of the Irishman exaggerating the great wealth of the miners and vainly boasting of his own successful expedition to the region of gold, for he had

but recently returned, and he showed his store of treasure to the covetous crew around him. Ah! little did he suspect that blood was on their hands, that Satan was again busily at work among them. With that vanity which generally leads man into a display of his wealth he exhibited his gold, the goods, too, he had bought for the winter's supply and comfort of his family; he was always poor before, but now may sit down and while away his time until the gold harvest again commences, quite at his ease. Here are silks and fine things for those who were poorly clad before, here is an abundance of food for those who were but lately half fed, and see, he has still a large store of treasure left.

"But come," he says, "sit down, boys, bring more wood and let us be comfortable." The two murderers brought out some of their ill-gotten gold, too, and their host bought it of them, paying down the cash. At length they yield to fatigue and rest in sleep. In the morning they partake of the comfortable breakfast which their host spreads before them, and for which, and for all his kindness, he will accept no compensation. They leave him at ten in the morning, but proceed a short way only on their journey when they halt. "It is a shame," says Banbury, "to let this chance slip by, we ought to have that money." He perhaps was only giving utterance to thoughts busily at work in the hearts of all, for with but few words they all turned back. "Boys," said Read, as they approached his door, "so you have all come back; that's right, come in and be comfortable, 'tis of no use to travel in such bad weather." "Yes," they replied, "our horses are jaded and we are pretty well worn out, and we are so very comfortable by your fire we have concluded to stay another day and rest ourselves." Evening came on and they busied themselves in cutting wood and assisting in the work of making each other comfortable for the night—cold-blooded villains, thus to be, as it were, gloating over their victims; but darkness alone will suit their works—they would recoil from such deeds in daylight, so they wait for night. Too soon it comes and throws its mantle over the scene, but by the red glare of the cheerful fire they sit and smoke their pipes and talk and laugh, while all the time hell is raging in their minds. Soon a dull leaden sound is heard—a blow, a groan, and the old man falls—Banbury has struck him on the head with the axe, twice or thrice the blow is repeated, and though life must be extinct, another of the murderous gang stabs him with a knife. An old Indian servant is sleeping on the floor; the axe soon sends him to

his final rest. "Come on," says Banbury, "there's more work to be done," and he opens the door of the bedroom where the mother and her children and the rest of the family are sleeping, but the noise has disturbed and alarmed them. "Buenas noches, señora," was the salutation of these villains as they entered the room, and now commenced again a most awful scene of butchery—all, all were slaughtered. I find my very thoughts stand still in attempting the recital, so awfully heartrending must have been the scene in that room. Mother and children—vainly do they beg for mercy where there is none; tears and shrieks and prayers that might have moved a heart of stone are all lost here where hell-hounds are at work and gold is the object.

One little fellow has crept under the bed—poor boy, better had he waited and suffered a more speedy death; he is shot at once or twice, and then dragged out to have his skull cleft. There is still one left, a little child, an infant, unconscious of what is going on. The wretch Banbury brought it out of the room saying, "I have not the heart to kill this child." What mockery! Another fiend at his elbow took the smiling baby, and going back to the room, soon returned, saying, "I quickly finished *that one*." And now they rifled the house of money and goods till all are laden with more than they can carry, for this plunder being dropped along their road served to trace them up. They are rich now, and after travelling a few miles buy fresh horses, for they must hasten out of that section of country. They met the dragoon mail-rider coming from Los Angeles to Monterey; he passed them, and in a few hours stopped at the scene of butchery. The stout heart of the soldier must have quailed, but no time was to be lost. He hastened to the nearest settlement, gave the alarm, and then resumed his journey, spreading the report through the country lying along his route with all the speed his horse could give him. He well described the five men whom he had met as being of a suspicious appearance and coming from the direction of the murdered family.

But let us return to the gang of cruel devils who thus in human form are travelling onward. Treason is at work among them, and surely vengence is at hand, for the country is aroused through an extent of a hundred miles or more. An Indian boy had attached himself to this gang and followed them from Soledad; he too had assisted in the murders. The day after they left the house of Read, guilty men as they are, each begins to suspect the other of treachery; but first their minds fall upon the Indian boy. A foul-looking fellow is

he, with his dusky skin and shock of wiry hair, with his filthy blanket hardly covering his naked legs; but he has keenness in his eye and soon detects the suspicious glances thrown towards him. "That boy must die," said one. "Not here," muttered another; but the boy reads their minds, and snake-like he crept away from their camp-fire that night, and was not missed by the watch till he was beyond their reach. He is a cunning fellow and takes the very road from which pursuit may be expected. He meets the pursuers. "Have you seen five men, boy, and what road are they on?" "Yes, I have come on the Santa Barbara road and met five men, Americans, on horseback." The gang pass by Santa Barbara and camped for the night a mile or so outside the town. No wonder they avoid the dwellings of human beings, for they are but beasts of the mountain, tigers of the most cruel kind. They rested that night and made merry on some liquor bought on the road. At early day they started again; but here comes the avenger!

They were hardly in the saddle and on their road ere they are assailed from every point by mounted men, who challenge and call on them to "halt." A shot of defiance was their reply, for they know the desperate situation in which they are placed, and now commences their turn for being put to death. Banbury and "Mike" fell in the melée; the former, having killed one of his assailants, leaped from a cliff into the sea, but he was wounded and the gold weighs him down; he cannot swim, and vainly he tries to reach the shore again, crying out for quarter. He sunk, and the cold wave closed over this icy-hearted villain whose moans were heard only in the sea-bird's cave.

Lynch, Reamer, and Quinn were captured and secured. The fury of the crowd which surrounded them was with difficulty restrained; a brave and gallant citizen had fallen in the pursuit. Don Ramon Rodriguez with his lasso had fearlessly dashed after one of these miscreants, lassoed and dragged him from his horse; the man in falling shot him, and the wretch Banbury also fired another shot; Rodriguez fell, but ere he died saw the whole party killed or captured.

The prisoners were judiciously placed in different rooms and safely guarded. A few days after their capture, the people of the town being ignorant how to proceed, were glad to see an officer and two dragoons ride in. A lieutenant had gone from Monterey in pursuit; he had taken the road for Los Angeles, and passed by Santa Barbara ere he heard of the affair there, so he hastily retraced his steps,

and on getting to that place, advised the good citizens how they should proceed to trial; for there is at this moment no regular administration of law in this territory, martial law having ceased and the civil not being established. It was well for the ends of justice that Lieutenant Ord arrived at this opportune moment, for the murderers had a chance of escape. In the first burst of passion on capturing the villains the populace were for wreaking upon them instant and dire vengeance without the formalities of trial; they wished at once to avenge the deaths of their friends, and it was with great difficulty they were restrained by those who desired rather to proceed calmly and according to the usages of law and good order. The prisoners were placed in close confinement, the tumult subsided, and the excitement being over, the people were at a loss how to proceed, for they were without organized courts, and in fact without any immediate right to place the criminals on trial. In this dilemma they began to relax somewhat in their vigilance, and at the time the officer arrived there was no watch kept on the prisoners. Lieutenant Ord called their attention to the matter and ordered that a hired guard should be kept at the prison house, and also gave the necessary advice and instructions with regard to the trial.

The three murderers were placed on trial, found guilty, condemned and executed within three brief days, and it was not a little remarkable that each one on trial stoutly denied his own guilt, but bore witness against the others; each one was an unwilling witness only in the terrible slaughter, each exclaimed against the butchery but was forced by the others to remain—this was the substance of the defense of all these villains; and there was some reason to suppose that in the case of Quinn there was a shadow of doubt as to his having entered willingly into the diabolical plot, but his hands did assist in the butchery, and his case is a striking illustration of the dangerous effects of bad company—it brought him to a felon's end.

March 14, 1849.—Let this day be long remembered as one of the bright days of my life—a day made bright and cheerful and happy by thoughts of home. I am now going home. We sailed for home at daybreak on the morning of this day, and though the winds be light we are on our way.

On the 16th February I sailed from Monterey in the Warren, and arrived at San Francisco on the fourth day after. The commodore was absent in the Southampton up the bay and did not return until the 23d February, after an absence of three weeks. Three or four

days after his return I was advised by Capt. Rudd to apply for the Dale in person. I had resolved that I would never make application to Commodore Jones, but for reasons which satisfied me I was induced by my friends to change my mind. I therefore called upon him one morning, and he without hesitation said he would order me back to the Dale. My friend Rudd had previously applied for me, but no satisfactory answer could be obtained. In the course of conversation with him he said, "Mr. Craven, I wanted to have a talk with you about a letter you wrote to me in Monterey and which I did not like." I replied, "Commodore, in writing that letter I did precisely as you would have done under the same circumstances." "Be that as it may—I don't know; but when I ordered you to the Warren I intended to bring you to a court-martial," said he; "but I advised with Capt. Stribling, and am perfectly satisfied that you intended no disrespect to me." I replied that I had at the time told Capt. Rudd that I had no intention of treating the commodore with disrespect, but considering my rights invaded, had under that feeling written the letter.

On the morning of our sailing I received from Commodore Jones messages by the captain and purser complimenting me on my survey at Monterey and saying he had intended writing me a letter on the subject, but his business had so completely occupied his time as to have prevented his doing so.

Valparaiso, May 25.—We arrived at Valparaiso on the 8th of May after a pleasant though tedious voyage of fifty-five days. We have been detained here three weeks waiting for Mr. Breton, our chargé d'affaires, who is going home with us. It seems that this worthy old personage has become enamored of a Chilian maid and has married her. The marriage ceremony was performed by the Presbyterian chaplain of the Independence, and in consequence of not having conformed with the forms of the Roman Catholic Church they have brought upon themselves the displeasure of the bishops and priests, who consider themselves outraged in the matter. Excommunication and a thousand other evils have been threatened the lady, and in her anxieties on the important subject old B. has fired up and quarreled with the whole community, Church, State and all. He in his turn has threatened a bloody and exterminating war, promising that the archbishop should be seized, taken to the United States and tried by court-martial; in other words, the old fellow has been making himself the laughing stock of society here. On the 20th of May they

arrived in Valparaiso; this loving pair, accompanied by her sister and maid, all to take passage to the land of freedom. Neither of them can speak the language of the other.

We were completely overwhelmed by the crowd of American emigrants here on their way to California, that "land of promise"; vessels coming in every day filled with passengers, who crowded about us when we were on shore, and who constantly visit us on board to inquire about the land where gold is plenty; wishing to see and touch those who had come from El Dorado, and be assured that their dreams of riches were not too highly gilded. Thousands are going to California, thousands must there meet with disappointment and despair, and thousands will never return to the happy land they have left.

May 30.—On the night of the 26th we sailed from Valparaiso for stormy Cape Horn, and at this moment our gallant little ship is most nobly speeding on her way towards the icy regions.

July 28.—To-day we are in 6° north latitude in the North Atlantic! Last night the north star was visible with its twinkling light, giving promise of our distant homes. To-day small quantities of "gulf weed" have been seen, and I really feel that we are drawing near to our own shores. God grant us a speedy and happy arrival, a happy reunion to our friends.

Sunday, August 19.—Last Sunday we had great hope that we should on this day or to-morrow arrive at New York, but have been disappointed in having light winds and calms; to-day, again our prospect is improving. We are now as I write some three hundred miles from home. Just think of the feelings one enjoys in the thought, one who has been so many thousands of miles distant, and so very, very long absent—it is difficult to realize. How many will be made happy by the arrival of our ship, how many hearts will beat with love and rejoicing! and, I regret to say it, to some we will bring most agonizing intelligence. Some who are daily and anxiously looking out for us, cheered by the hope of being speedily reunited to the absent ones, will only hear of our arrival to learn that man proposes but God disposes. In the neighborhood of Cape Horn our sergeant of marines died, a married man, leaving a wife in Poughkeepsie; his illness was of some weeks, the revival of an old chronic dysentery.

And now again, when so near home, our ship has been overcast with gloom by a very sudden death among us—Midshipman W. B. Hayes, a young gentleman of very bright promise, great intelligence,

and one of the most correct youths I have ever seen. He was taken ill with a violent fever which, though somewhat alarming, did not seem attended with danger. On the tenth day, however, he was pronounced by the doctor as convalescing, but all were deceived; his constitution was too delicate, the fever had done its work and left him nearly exhausted, and on the twelfth day, much better in the morning and in fine spirits, he was taken at noon with hemorrhage of the bowels and died before night, August 10. What a sad blow to his family, of whom, I am told, he was the idol. I have often thought how great would be the happiness of his mother and the many who so loved him on seeing him return—a man, who had not forgotten *one* of the good precepts taught him in youth. He was most deservedly a favorite with every person; officers and men were alike fond of Hayes; but the unerring shaft has singled him out from among us, and God grant that our minds may be thus brought to a more close consideration of the uncertainty of life, the vanity of all earthly pleasures.

I thank my God that health and life have been continued to me, and pray that my heart may increase in fervent devotion to Him who is the giver of all good things.

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A NEW METHOD OF REDUCING CHRONOMETRICAL LONGITUDES.

By Ensign A. B. Clements, U. S. N.

Observations for the determination of the longitude of the mouth of the Keum river, Korea, were made by the officers of the U. S. S. Alert, in June, July, and August, 1884. The Alert being at that time a regular cruising vessel of the Asiatic Station, her other duties prevented her making more that one round trip from Nagasaki, the origin of longitudes, and from remaining there long enough to rate chronometers either before or after visiting the undetermined points. The sights obtained were as follows: At Nagasaki, June 14.5, equal altitudes for error; at Chemulpo, June 27 and July 8, equal altitudes for error and rate; at Keum River, July 23 and August 3, equal altitudes for error and rate; at Nagasaki, August 13.5, equal altitudes for error.

The Alert carried five chronometers, 1349, 1636 and 1458 Negus, 372 Hutton, and 2171 Poole. On working up the longitudes of Chemulpo and Keum River by the methods and formulæ published by the Department and given in the books of reference, a great divergence in results by the different chronometers was found and a better method shown to be necessary. While investigating this subject I was, by the courtesy of Professor Wm. Harkness, U. S. N., allowed to examine his manuscript, dated August 28, 1886, yet unpublished, of the reduction of chronometrical longitudes in connection with the Transit of Venus expeditions. This, I believe, was a new application of the method of least squares to chronometer rates in the determination of longitudes, and led me to examine into the applicability of least squares to the general problem of the reduction of chronometrical longitudes. I was soon satisfied it could be used

with great advantage and offered a satisfactory and general solution, adaptable to any circumstances that might arise in cruising, and utilizing to the best advantage any data that might be obtained, however meagre.

The following is the solution of the general problem, with the special case of the Alert at Chemulpo and Keum River as an example.

Suppose a vessel starting from a position A whose longitude is known, touches at several places X, Y, Z, etc., whose longitudes are unknown, and finally at B whose longitude is known; that sights for error of chronometer on local mean time are taken at each place and that at some of them sights for rate also, and that the longitudes of X, Y, Z, etc., are wanted.

We will assume the notation of the following table:

Name of Station.	Longitude.	Correction to Local Mean Time.	Interval between Sights.	Rate.
A	L_a	C_a		
			Δ_a	r_a
A	L_a	C_a'		
			Δ_{ax}	$R_{ax}+v_1$
X	L_x	C_x		
			Δ_x	r_x
X	L_x	C_x'		
			Δ_{xy}	$R_{xy}+v_2$
Y	L_y	C_y		
			Δ_y	r_y
Y	L_y	C_y'		
			Δ_{yz}	$R_{yz}+v_3$
Z	L_z	C_z		
			Δ_z	r_z
Z	L_z	C_z'		
			Δ_{zb}	$R_{zb}+v_4$
B	L_b	C_b		
			Δ_b	r_b
B	L_b	C_b'		

R_{ax}, R_{xy}, R_{yz} and R_{zb} are assumed from such known rates r_a, r_x, r_y, r_z and r_b as have been determined corrected for temperature, etc., and v_1, v_2, v_3 and v_4 are unknown corrections to reduce the assumed rates to most probable ones.

Each trip will give an observation equation as follows:

A to X, $\quad C_a' + \Delta_{ax}(R_{ax}+v_1) + L_a - L_x - C_x = 0.$ (1)

X to Y, $\quad C_x' + \Delta_{xy}(R_{xy}+v_2) + L_x - L_y - C_y = 0.$ (2)

Y to Z, $\quad C_y' + \Delta_{yz}(R_{yz}+v_3) + L_y - L_z - C_z = 0.$ (3)

Z to B, $\quad C_z' + \Delta_{zb}(R_{zb}+v_4) + L_z - L_b - C_b = 0.$ (4)

Adding and putting

$$W = C_a' + C_x' + C_y' + C_z' + \Delta_{ax} R_{ax} + \Delta_{xy} R_{xy} + \Delta_{yz} R_{yz} + \Delta_{zb} R_{zb} + L_a - L_b - C_a - C_y - C_z - C_b$$

the known quantities, we have

$$W + \Delta_{ax} v_1 + \Delta_{xy} v_2 + \Delta_{yz} v_3 + \Delta_{zb} v_4 = 0. \quad (5)$$

This is the only equation of condition and must be satisfied exactly.

From the theory of least squares,

$$v_1^2 + v_2^2 + v_3^2 + v_4^2 = \text{a minimum}. \quad (6)$$

Substituting the value of v_1 from (5) in (6),

$$\left(\frac{W + \Delta_{xy} v_2 + \Delta_{yz} v_3 + \Delta_{zb} v_4}{\Delta_{ax}}\right)^2 + v_2^2 + v_3^2 + v_4^2 = \text{a minimum}. \quad (7)$$

Differentiating (7) with respect to v_2, v_3 and v_4 separately and equating to zero to find minimum values,

$$\frac{2(W + \Delta_{xy} v_2 + \Delta_{yz} v_3 + \Delta_{zb} v_4)\Delta_{xy}}{\Delta_{ax}^2} + 2v_2 = 0, \quad (8)$$

$$\frac{2(W + \Delta_{xy} v_2 + \Delta_{yz} v + \Delta_{zb} v_4)\Delta_{yz}}{\Delta_{ax}^2} + 2v_3 = 0, \quad (9)$$

$$\frac{2(W + \Delta_{xy} v_2 + \Delta_{yz} v_3 + \Delta_{zb} v_4)\Delta_{zb}}{\Delta_{ax}^2} + 2v_4 = 0. \quad (10)$$

From which $\frac{v_2}{\Delta_{xy}} = \frac{v_3}{\Delta_{yz}} = \frac{v_4}{\Delta_{zb}}$, and since (5) and (6) are symmetrical, equals also $\frac{v_1}{\Delta_{ax}}$.

Substituting for v_2, v_3, v_4 in equation (5) and putting

$$K = -\frac{W}{\Delta_{ax}^2 + \Delta_{xy}^2 + \Delta_{yz}^2 + \Delta_{zb}^2},$$

$$v_1 = K\Delta_{ax},$$
$$v_2 = K\Delta_{xy},$$
$$v_3 = K\Delta_{yz},$$
$$v_4 = K\Delta_{zb},$$

and substituting these in (1), (2), (3) and (4), we get the differences of longitude $L_a - L_x$, $L_x - L_y$, $L_y - L_z$ and $L_z - L_b$.

Should the vessel after leaving B return to X, Y, or Z, and thence to a position of known longitude, each trip will give another equation of the form of (1), (2), (3) and (4), and each round trip, from a known

position to the same or another known position, or from an unknown to the same unknown, will give an equation of condition of the form of (5), and these may be proceeded with in two ways:

1. These several equations of condition may be substituted in the general least square equation

$$v_1^2 + v_2^2 + v_3^2 \quad . \quad . \quad . \quad . \quad + v_n^2 = \text{a minimum},$$

eliminating as many of the v's as there are equations of condition, thence differentiate, equate to zero and proceed as in (8), (9), (10), etc.; or

2. Take each round trip, as explained above, as a separate problem, and solve for the v's and the longitudes, and take the weighted mean of the longitudes as the true longitude. The appropriate weight in this case would be the reciprocal of the square of the time occupied in the round trip.

For the case of the Alert, referring to the previous notation table, we have:

Station.	Longitude.	Correction to L. M. T.	Interval.	Rate.
Nagasaki	L_a	C_a'		
			Δ_{ax}	$(R_{ax}=r_x)+v_1$
Chemulpo	L_x	C_x		
			Δ_x	r_x
Chemulpo	L_x	C_x'		
			Δ_{xy}	$[R_{xy}=\frac{1}{2}(r_x+r_y)]+v_2$
Keum River	L_y	C_y		
			Δ_y	r_y
Keum River	L_y	C_y'		
			Δ_{yb}	$(R_{yb}=r_y)+v_3$
Nagasaki	L_a	C_b		

$$C_a' + \Delta_{ax}(r_x + v_1) + L_a - L_x - C_x = 0, \tag{1}$$

$$C_x' + \Delta_{xy}[\tfrac{1}{2}(r_x + r_y) + v_2] + L_x - L_y - C_y = 0, \tag{2}$$

$$C_y' + \Delta_{yb}(r_y + v_3) + L_y - L_a - C_b = 0, \tag{3}$$

$$W = C_a' + C_x' + C_y' + \Delta_{ax}r_x + \frac{\Delta_{xy}r_x}{2} + \frac{\Delta_{xy}r_y}{2} + \Delta_{yb}r_y - C_x - C_y - C_b,$$

$$W + \Delta_{ax}v_1 + \Delta_{xy}v_2 + \Delta_{yb}v_3 = 0, \tag{5}$$

$$K = -\frac{W}{\Delta_{ax}^2 + \Delta_{xy}^2 + \Delta_{yb}^2} \text{ and } v_1 = K\Delta_{ax},$$

$$v_2 = K\Delta_{xy},$$

$$v_3 = K\Delta_{yb}.$$

Computation of Longitudes, Keum River and Chemulpo.

	1349 Negus.	1636 Negus.	1458 Negus.	372 Hutton.	2171 Poole.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
C'_a	— 15 21 09.8	— 15 22 43.5	— 15 05 21.3	— 15 19 00.3	— 15 23 01.8
C_x	— 15 34 26.0	— 15 36 07.5	— 15 18 25.5	— 15 32 17	— 15 36 06.5
C''_a	— 15 34 40	— 15 36 29.7	— 15 18 27.5	— 15 32 32.5	— 15 36 11.5
C'_x	— 15 34 44.5	— 15 36 35	— 15 18 11	— 15 32 29.5	— 15 35 56
C'_y	— 15 34 58.2	— 15 36 42	— 15 18 05.7	— 15 32 31.5	— 15 35 50
C_b	— 15 22 25.8	— 15 34 03.7	— 15 05 18.5	— 15 19 48.5	— 15 23 02.8
Δ_{ax}	12.5 days.	12.5 days.	12.5 days.	12.5 days.	12.5 days.
Δ_x	11 "	11 "	11 "	11 "	11 "
Δ_{xy}	15 "	15 "	15 "	15 "	15 "
Δ_y	11 "	11 "	11 "	11 "	11 "
Δ_{yb}	10.5 "	10.5 "	10.5 "	10.5 "	10.5 "
$R_{ax} = r_x$	— 1.27272 s.	— 2.01818 s.	— 0.18181 s.	— 1.40909 s.	— 0.45454 s.
$R_{xy} = \frac{r_x + r_y}{2}$	— 1.25909 "	— 1.32727 "	+ 0.15000 "	— 0.79545 "	+ 0.04545 "
$R_{yb} = r_y$	— 1.24545 "	— 0.63636 "	+ 0.48181 "	— 0.18181 "	+ 0.54545 "
W	+ 0.42727 "	— 0.81818 "	+ 5.53636 "	— 0.95454 "	+ 2.72727 "
K log	6.93918n	7.22133	8.05170n	7.28828	7.74422n
v_1	— 0.01086 s.	+ 0.02081 s.	— 0.14080 s.	+ 0.02428 s.	— 0.06936 s.
v_2	— 0.01304 "	+ 0.02497 "	— 0.16895 "	+ 0.02913 "	— 0.08324 "
v_3	— 0.00913 "	+ 0.01748 "	— 0.11827 "	+ 0.02029 "	— 0.05827 "
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	h. m. s.
$L_a - L_x$	+ 0 13 00.2	+ 0 12 59.0	+ 0 13 00.2	+ 0 12 59.4	+ 0 12 58.2
$L_x - L_y$	— 0 00 14.6	— 0 00 14.2	— 0 00 16.8	— 0 00 14.5	— 0 00 16.1
$L_y - L_a$	— 0 12 45.6	— 0 12 44.8	— 0 12 43.4	— 0 12 44.9	— 0 12 42.1

Mean Values.

$L_a - L_x$ + oh. 12m. 59.40s.
$L_x - L_y$ — 0 00 15.24
$L_y - L_a$ — 0 12 44.16

Assuming L_a, the longitude of the observation spot, Akanura Factory, Nagasaki, Japan = 8h. 39m. 24.87s. E., then, applying the mean values, we have

Long. So Wolni Island, Chemulpo, Korea,

$$L_x = 8\text{h. } 26\text{m. } 25.47\text{s. E.} \pm 0.23\text{s.}$$

Long. Changoom Head, Keum River, Korea,

$$L_y = 8\text{h. } 26\text{m. } 40.71\text{s. E.} \pm 0.42\text{s.}$$

Though no observations for rate were taken at the origin of longitudes, and all the chronometers but one suffered great changes of rate, the sign of the rate in two of them being changed, the agreement in the results by the different chronometers is most satisfactory.

It is believed that the use of the above method will be less laborious for the surveying officer than the old methods, as well as enabling him to arrive at valuable results from observations that would otherwise be worthless.

The question of weights is not mentioned above, but it may be shown that equation (6) is really weighted as it should be. Thus, if the observation equations (1), (2), (3), and (4) are reduced to the same weight by dividing them by Δ_{ax}, Δ_{xy}, Δ_{yz}, and Δ_{zb} respectively, v_1, v_2, v_3, and v_4 will be the residuals, and equation (6) will express the general least square equation,

$$[pvv] = \text{a minimum.}$$

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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

FEBRUARY 2, 1888.

COMMANDER P. F. HARRINGTON, U. S. NAVY, in the Chair.

THREE CONSIDERED AS A TACTICAL UNIT.

By LIEUTENANT D. H. MAHAN, U. S. Navy.

I.—INFANTRY.

In bringing this subject to the notice of the Institute I am actuated by the feeling that the tactics now in use are not adequate for the present day. This inadequacy has been brought about by the entire change in weapons for offensive and defensive work. Rapid-fire cannon will soon be the rule and not the exception, and the magazine rifle will, I think, soon be in general use. A man armed with one of these rifles becomes as much more dangerous as the number of charges in the magazine supplied to him is increased.

Before proceeding farther I should like to read a few extracts from a lecture delivered by Col. J. H. A. Macdonald, Commandant, Queen's Volunteer Brigade of Edinburgh; it contains many very interesting and important points apart from those I wish to bring to your notice. He says:

"Is it possible, in this day of long range rapid firing, to move either the log of the column or the plank of the line so as morally to impress the enemy, or physically to force him off his ground by a continuous advance in a shoulder-to-shoulder fashion? The thing is impossible. The force must move forward in separate portions, feeding the fighting line and bringing it up to the strength necessary for shock. Can this be done by the present style of drill, by the march past, or by the dress parade? If it cannot be done, then our present system of drill is wrong, for we think more of the parade than of efficiency, and appearances are aimed at instead of realities. Time spent on that which is unavailable for use is time wasted; habits acquired which are not consistent with comparative conditions are harmful and dangerous habits. If reliance on touch is made a soldier's second nature,

his *morale* will suffer when he finds that that on which he has been taught to rely is never available. General Wolseley says, 'I think it a very dangerous thing to teach a soldier in peace anything which he is not likely to practice in war.' Whatever has been made a man's second nature will come out when his nerve is tried. How different from the old touch and parade movement is the advance in battle of the present day! The actual advance under fire may be two miles or more, which must be covered at speed, and when a counter or flank attack must necessarily, as Von Moltke points out, move upon an arc of a circle of several miles radius before it can commence to develop its attack. An interval order, besides being most suitable for the conditions of modern fire, saves from all unnecessary fatigue. There is no straining after mathematical accuracy. There is no jostling and pressing. One may say, But if we give up the parades and fancy drills how shall we employ the men's time? Let such a one consider what Prince Hohenlohe says, 'One should not attempt artificial combinations, but rather spend the time in repeating the simple routine [by which the context shows he means a real action exercise] hundreds and thousands of times. Thus, and thus only, can you feel sure that what you require will be done before the enemy.' Men moving with an interval between them can be drilled, and have been drilled, to as great steadiness and accuracy of movement as they have ever been brought to in close files. Troops should be trained to move as accurately, as strictly, and as firmly in discipline in open order as they now do in close files. Thus, and thus only, will they safely acquire the flexibility of the action exercise, controlled by strict discipline, and yet modified by an intelligent application of the drill to its work, thus enabling the officer to keep his implements of warfare under control.

"The following are some points which demand attention in adapting infantry drill to modern requirements:

"1. A simplification of the formations, giving the utmost freedom of movement and developing an individual order.

"2. All infantry work to be studied in relation to the character of the modern warfare; the hard and fast line which now separates the parade drill from the practical exercise being removed, and rapid and frequent change from the one to the other being a distinct feature of the training.

"3. A general principle for advancing into action which would apply to all bodies of men, large and small, so as to maintain cohesion from the highest officer down to the single private.

"4. A direct movement after the troops were deployed for action, so that they should not be required to manœuvre under the terrible fire of modern weapons, but should be free to push forward as required according to the ground.

"5. Adjustment of all details, so as to give speed of movement, while saving the troops from all unnecessary fatigue.

"6. In addition, a thorough command, a development of comradeship in small groups, giving rallying power to small parties. This is the essence of restoring order in large bodies suffering from disintegration during the conflict.

"7. Training in the athletic sense to be a distinct aim in all drill.

"8. Knowing what we can do as soldiers, we shall lose our advantage if we do not take the lead of others, and we can only do so by promptly deciding how far we may, with prudence, develop our drill in a new direction, and then boldly and unhesitatingly taking the step our own judgment commends with independence and courage."

The first and sixth of these points first called my attention to the possibility of three being an important factor in the tactics of the future. In many other instances we find three as a factor of much importance. In the human body we have the head, with the two legs as motive power and the two arms as weapons of defense. In the fleet we have the centre, with the van and rear. In infantry drill we find the captain and two lieutenants assigned to the company, the one acting as the head, the other carrying out what the head commands. Taking three men now as the unit, these three are to work continually together, although separated by slight intervals when in battle action. By the combination of threes the successive gradations are made, increasing to the section, the company, battalion, regiment, brigade, division, and army corps if desired.

Beginning with three men, they should be "trained in the athletic sense," and taught all possible movements in open order as well as in close order. Having become habituated to this, they may (by joining several units) be formed into the section; the section to be composed of three units of three for the front rank, as also three units of three for the rear rank. Hence a unit equals three men; a group equals six men or two units, one front rank, the other rear rank. In the section the same mode of drill should be continued, attention being paid while in the open order more to the way of performing the movements than to the mathematical accuracy of the interval. From a combination of three sections the company is formed; so we have for the company three sections, each composed of three units for each rank,

or a total of 18 men. To every section it is desirable to allow three non-commissioned officers, call them sergeants or corporals as you please. Having combined the three sections, we have a company of 54 privates and 9 non-commissioned officers, or a total of 63 men. The officers assigned should be a captain and two lieutenants.

By the combination of three companies the battalion is formed. The regiment (brigade for naval work) would consist of three battalions. This, I think, is as far as is necessary for the combination to extend for the naval branch of the military force; increasing, however, as shown in the following table, for the organization of an army:

Organization.	Privates.	N. C. Offs.	N. C. Staff.	Officers.		
				Company.	Staff.	Field.
Company, peace	54	9	...	3	...	...
" war	108	9	...	3	...	...
Battalion, peace	162	27	3	9	2	1
" war	324	27	3	9	2	1
Regiment or N. Brigade, peace	486	81	12	27	8	5
Regiment or N. Brigade, war	972	81	12	27	8	5
Brigade, peace	1458	243	36	81	24	15
" war	2916	243	36	81	24	15
Division, peace	4374	729	108	243	72	45
" war	8748	729	108	243	72	45

The company shall consist of 1 captain, 2 lieutenants, 6 sergeants, 3 corporals, 54 or 108 privates.

The battalion shall consist of 1 major, 1 battalion adjutant, 1 battalion quartermaster, 1 battalion sergeant-major, 1 battalion quartermaster-sergeant, 1 battalion commissary sergeant, and three complete companies.

The regiment or naval brigade shall consist of 1 colonel, 1 lieutenant-colonel, 3 majors, 27 captains and lieutenants, 2 surgeons, 1 adjutant, 1 quartermaster and commissary, 1 sergeant-major, 1 quartermaster-sergeant, 1 commissary sergeant, 3 battalion sergeant-majors, 3 battalion quartermaster-sergeants, 3 battalion commissary sergeants, 54 sergeants, 27 corporals, and 486 or 972 privates.

The brigade shall consist of 1 brigadier-general, 1 assistant adjutant-general, 1 chief commissary, 1 chief quartermaster, 1 surgeon in chief, 6 surgeons, 2 aides to general, 7 hospital stewards, and 3 full regiments.

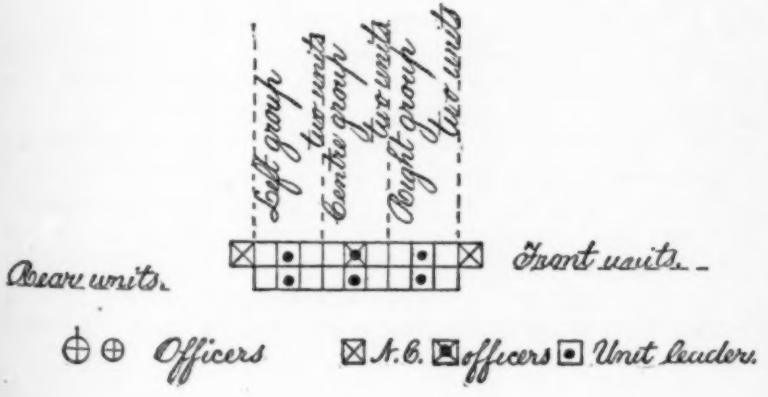
The division shall consist of 1 major-general, 1 adjutant-general, 1 chief quartermaster, 1 chief commissary, 1 inspector-general, 1 chief engineer, 1 medical director, 1 chief of ordnance, 3 aides to major-general, and 3 full brigades and brigade staffs.

An aide can be added for Naval Brigade.

To the Division should be added an Ambulance Corps of 30 men capable of division into parties of 10 men each for brigades if necessary.

Let us consider what is necessary to work up to the movements in open order or battle action. The recruit, after his setting up drill has been completed, should be taught the facings, right, left, and about, both on the march and at a halt. In the unit of three he should be drilled both in open and close order, in changing direction at double time and at quick time, to such orders as these: "To the right (left or rear), march"; remembering always that "they should be trained to move as accurately, as strictly, and as firmly in discipline in open order as they now do in close files."

The movements of the unit then, both for close and open order, are these: "To the right (rear or left), march"; "right (or left) oblique, march"; "halt"; "right (left or about) face"; "forward (backward or double time) march"; and "deploy." This last will need explanation. Deploy is used here as the word of command which causes the units or groups to pass from the close to the interval order, or, in other words, it brings the men from a position such that their elbows touch, to one in which they are from three to five paces apart. The deploy will be executed in the following way: For the unit the centre man will advance straight to the front, the right man moves quickly to the right and front until he has attained three or five paces from the centre man, the left man moves quickly to the left and front until he has also attained the same distance from the centre man, then all move forward until the order halt. For the group, the front rank moves as above; the rear rank unit runs quickly to the left and front about fifteen paces and then deploys in same manner as front rank unit. Passing now from the unit and group to the first combination of three or the section, we find the units and groups arranged as follows:



In this drill it is desired that there should be no fixed front rank; whichever rank happens to be in front is the front rank, the other the rear rank. Then for the section or company marching in column, if the order be given "To the right (or left) front into line," it will make no difference whether the section or company is marching right or left in front, for there will be the section or company formed in section or company front with the centre group or centre section in the centre, and one group or one section on the right and one on the left. The same men still form the division line between the groups and sections, and it is only necessary for the lieutenants to keep their wits about them.

It is proposed now to manœuvre this section in all necessary ways, and to arrange a systematic tactics so that, having these manœuvres, they may be as applicable to the company, battalion, and brigade as they are to the section itself. The changes of direction for a section should be made always by a "To the right (or left), march"; "Groups right (or left), march"; "Sections right (or left), march"; the first being a flank movement and the two last wheels. If at a halt the first order would change to "Right (or left) face." With "Column right (or left), march," one will be enabled to manœuvre the section into any position required. All changes to the rear are to be performed by either "about face," or "to the rear, march." It is not desired to wheel by groups to the rear.

The foregoing are the close order movements, but they can be used as well with the open or battle order. To arrive at the open order it will be best to deploy the section into the group formation, and preferably on the centre group; however, that can be left to the discretion of the commanding officer. The order will be as follows: "On the centre group, for battle action, double time, march." (See Plate I.) The centre group moves forward at quick time, the right and left groups oblique respectively to the right and left at double time about 18 (or 30) paces and come up abreast the centre group, when they take quick time. On reaching the group lines the non-commissioned officers, who have thus far conducted the right and left groups, fall to the rear 10 paces and exercise supervision over their respective groups; the lieutenant in charge of section, while commanding all, looks out principally for the centre group. The advance in groups continues until such time as the officer in command deems it advisable to "deploy." Upon this order being given, either by word or bugle, each group will separate in the following way: The front

unit of each group will advance, the centre man forward, the right man right oblique, the left man left oblique, until each man is separated from the centre man by 3 (or 5) paces. The rear unit will oblique quickly to the left and deploy in same manner as front unit, coming into the interval on the left of each front unit. Each unit will then occupy a space of 9 (or 15) paces. The centre man of each unit ⊡ will be the leading man of that unit; if it is desired to concentrate fire on any one spot he will be the one to direct and to give the word to fire. If the members of fire line rally to fire, as soon as their fire has been delivered they will immediately deploy, keeping in motion (unless under cover) as much as possible so as to disconcert the enemy's fire.

Should the order be "On the right (or left) group, for battle action, double time, march" (see Plate II.), the right (or left) group moves forward at quick time, the others oblique at double time to the left (or right) until the centre group has proceeded 18 (or 30) paces and the left (or right) group 36 (or 60) paces, and then forward until abreast of group on which deployed. The deployment of units takes place when desired. If the section should be marching by the flank, say, for instance, on a road, and a field should be reached which it would be desirable to occupy, the command would be, "To the left (or right) front into line, for battle action, double time, march." (See Plate III.) The leading group forms into group front, the centre group coming into position 18 (or 30) paces to the left (or right) of the leading group, and the rear group 36 (or 60) paces to the left (or right) of leading group. In one instance the rear rank would be in front, but it would not change the men, as the same three always act together with the same man as the centre man, and the deploy movement is always the same, that is, the front rank unit deploys forward, the rear rank unit to the left and forward.

The section should be drilled in all the movements as though in close order: to wheel, to march by the flank, to advance and to retreat. To rally by threes and by sixes for unit or group volleys, and to deploy as soon as the fire has been delivered. To advance by rushes of 10 paces, the front rank units to advance while the rear rank units open fire; as soon as the front rank commences to fire the rear rank is to advance, passing the front rank by 20 or 30 paces and taking advantage of any possible shelter. In all these advances by rushes *the three* should be the only element of accuracy; the leader of each unit, however, being careful that he does not get too far in

advance of the line. The assemblies or rallies should not take place at the same time along the line; in some cases the guide of a group might rally the front and rear units (the rally should then be made on the leader of front unit, unless better cover could be found; the guide in that case should proceed to that cover and have the units rally or assemble on himself). No rigid rule can be laid down for any of these manœuvres, but I think it may be said that the day of rallying by companies is nearly over. Sir Lumley Graham says: "Good infantry need not fear the attack of cavalry, even if in extended order. As a general rule they should be able to maintain the formation in which they happen to be when threatened. To do otherwise would only be to play the enemy's game." By massing the troops you make a larger target and expose yourself to a greater percentage of loss. A man when compelled to depend upon himself will generally retain his self-possession; but rally them and let a panic of firing commence, the men will lose their coolness and it will take them some time after the deploy to calm down.

Having seen that the deployments can be made in any way in advance, deployments by the flank should be noticed, and also a deployment to the rear in order to provide for a surprise, when deployment to the front or flanks might be impossible. By looking carefully at the deployments marked *A* and *B* (see Plate IV.), it will be seen that after the deployments and the order "halt" is given the men will occupy the same relative positions.

To deploy to one flank, or to both flanks, the order will be, "For battle action, to the right (or left) flanks, double time, march," and will designate the evolution which is to be performed.

Let us consider the section deploying in obedience to this order, "For battle action, to the left flank, double time, march." At the order "to the left flank" the section, with the exception of the right guide, faces to the left, the left guide placing himself in front of the rear rank. At the order "march" the left guide steps off at double time, followed at intervals of 3 (or 5) paces by the left man of the left rear unit, he in turn followed by the centre man of same unit, and he by the right man of same unit. As soon as the rear unit has passed ahead, the front unit deploys in the same way; then rear centre unit, front centre unit, rear right unit, front right unit. At the order "halt" the men face to the front, guides stepping to rear.

Should the order be "to the right flank," the left guide stands fast, the others face to right. At order "march" the right guide steps

off at double time, followed by front right unit, then rear right unit, etc., at intervals of three (or five) paces.

Should the order be "to the right and left flanks," the section would deploy on the centre front rank leader. The left flank would consist of all the left group, the rear unit of centre group, and the left man of the front centre unit; all these will face to left. The right flank would consist of right group and the right front rank man of centre group; these would face to right. Led by the respective guides, they would take up the double time at intervals of 3 (or 5) paces at the order "march."

The assembly will be performed on the centre man, the left guide, or the right guide, as the case may be. The centre man is always in position. The guide named as the one on whom the assembly will be made advances at once to the battle line, and on him the men assemble.

The deployment to the rear will be, "For battle action, on centre (right or left) section (or company), to the rear, double time, march"; or "to the rear, deploy." If the first order is given, the men face to rear at the order "to the rear," and then deploy as provided for in deployment in advance. If the second order is given, the men deploy at once; the centre group is *the one* on which the deployment is *always* made when this order is given. The retreat is continued until the order halt is given. At "halt" the men face about and fire on the advancing enemy; if the retreat is to be continued, the front units will continue the fire, the rear units moving 10 paces at double time to the rear, then the front units, and so on. If the order "halt" be now given, the line is formed on that portion nearest the enemy. The only change made is a gain of 9 (or 15) paces to the right in the retreat movement (see Plate IV.).

In the drill of the section the system of three is still carried out, the lieutenant and two non-commissioned officers bearing the same relation to one another as the captain and two lieutenants.

So far the drill has been for troops in double rank. As many favor a single rank formation, it only remains to be said that if drilling in single rank, the distance between groups would have to be diminished. I prefer the double rank formation, as it is the intention to deploy into the battle or single line at a sufficient distance from the enemy to prevent the disadvantages of the double line.

In summing up, then, for the section I have endeavored (as desired in the sixth point) to have a "thorough command" throughout,

with "a development of comradeship in small groups," and also "to give the rallying power to small parties," which "is the essence of restoring order in large bodies suffering from disintegration during the conflict."

The Company.

Passing now from the section to the company, or the second combination of threes, the company is found to consist of three complete sections, that is, of 54 privates, 9 non-commissioned officers, and 3 officers—one captain and two lieutenants.

The formation (see Plate V.) shows the company as facing to the front. Immediately on the company being formed it will be the duty of the lieutenants to divide the company into the three sections, thus doing away with counting off. The first lieutenant counts from the right of the company nine and there indicates the left of the right section and the right of the centre section; the second lieutenant now takes up the count, and counting nine shows the division between the centre and left sections. The men have no numbers to remember, and the file closers, marching directly in the rear of dividing line, will see those divisions strictly carried out. In case of an incomplete number the left rear rank unit will either be incomplete or omitted. The right and centre groups of sections must be held complete throughout in every organization. In case of marching "to the rear," or of "about face," the left unit always comes into front rank. In counting off the sections the lieutenants count one, two, three; one, two, three; one, two, three. No. 2 is always centre man. If thought best, a guide can be put in the front rank at each point of division; then the right guides of all sections and the left guide of the extreme left section will always be in place. This, however, is not considered necessary.

In addition to the movements of the section, we require to deploy the company into the open order. The company being faced to the front, command, "On the centre section for battle action, double time, march." (See Plate V.) At the order "march" the centre section under the immediate command of the captain moves forward, quick time. The right section under command of the first lieutenant, and the left section under command of the second lieutenant, move respectively to the right and left oblique at double time until 54 (or 90) paces from the centre section and abreast of it, when they will take the quick time. Each officer gives the command, then, "On the centre group, for battle action, double time, march." This is

performed as shown previously. The order "deploy" will be given by the captain whenever necessary. The advances when the company is deployed will be by rushes of sections, the officers in command giving the order to advance. The centre rushes first, covered by the fire of the right and left sections, followed by both the right and left, or, if the opposing fire is very heavy, by only one section at a time. As has been said before, there can be no fixed rule given as to the time to start the rushes, which section to advance first, or how far to advance.

In case of a surprise, and a sudden deployment into the battle line be necessary, the order will be "Deploy into battle action." At this order each leader of a unit will start to right, left, or forward, as the case may be, followed by his two flanking men, separating, however, to a slight extent. After a little practice it will be found that the men will appear in about their proper intervals and places in the battle line. Proper shelter is the first thing a unit leader should look for in case of a deployment by reason of a surprise. For the company there may be a few other developments, but, since simplification of both formation and evolution is sought after, they should be confined to two or three in addition to those already mentioned. The same order can be used whether the company is moving by the flank or in column of groups or sections, and it is desired to bring it into company front, *i. e.*, "To the right (or left) front into line," and also "On the right (or left) into line." In all these movements the centre is always the centre, and in the manœuvring much depends on the captain and lieutenants. In all rally and assembly formations the men repair on the run to their proper positions in whatever formation has been ordered. The rally should mean only one volley and then deploy. Any assembly should be deployed by the officer ordering the assembly. With the men on the firing line, neither the rally nor the assembly is favored. The unit or group may be allowed to rally or assemble for a concentrating fire if sufficient cover offer.

The Battalion.

The battalion is the third combination of three, or, in other words, a battalion consists of three companies. The officers and non-commissioned officers of the battalion are three times those of the company, and in addition thereto, one major in command, one adjutant, one doctor, one sergeant-major, and one quartermaster-sergeant.

The manœuvres of the battalion should approach as near as possible to those of the company and the section, with the addition of a few necessary for the management of so large a body of men. On the simple manœuvres it is unnecessary to dwell, so let us turn our attention to the interval or battle order for the battalion. The first order given, "On the centre (right or left) company, for battle action, double time, march," will designate the company which is to make the forward movement. The others will move as given in the case of sections from a company, only the intervals will be 162 (or 270) paces between companies. As soon as these positions are gained, company officers will deploy in section formation, then into group, and finally, when necessary, into the firing line. At this time we have the battalion (which from a far off distance has been gradually approaching the enemy, and which, as the danger of casualty increased, has been gradually reducing the size of the body opposed to the enemy's fire) ready at a signal to throw each man on his own resources as it were, or, in other words, to form a single line of skirmishers 3 (or 5) paces apart. In this I think is nearly solved the third point, which requires "a general principle for advancing into action which would apply to all bodies of men, large or small, so as to maintain cohesion from the highest officer down to the single private." By looking a little closer it will be seen that the major has his three captains; they in turn exert an influence, with the aid of their lieutenants, over the companies; the captain and lieutenants, with the aid of non-commissioned officers, over the sections, each one of the officers and non-commissioned officers over a group, and when a group is deployed there remains the cohesion of the three men forming the unit or factor for tactical work.

It must be remembered that as soon as the groups are deployed the rushes must commence, for by this time it is supposable that the line of fire, which the battalion has now become, has approached so near the enemy as to render it necessary to take advantage of any shelter possible. Now comes in the advantage of supporting one another. The three working together gives to each one of them more confidence, for each feels that he has two pairs of eyes besides his own to guard against surprise. In falling back the groups should not be assembled until well away from the zone of fire; then assemble by groups, sections, companies, and finally to the battalion. The assemblies should always be made towards the centres. Groups assemble from the fire line on the centre man of the front unit, the

man on whom they deployed. Sections rally or assemble on the centre group; companies on the centre section, and battalions on the centre company. The preceding mode of deployment is one that could be used over an open space from the battalion either drawn up in line of battle or in column of companies. If in column of companies, the first order would be "Companies to the right (or left) for battle action, double time, march." As soon as this order had been carried out the other orders would follow as before. Suppose, however, that the battalion was in column of companies and the space was too limited to allow the whole battalion to be deployed as just described, but it was *necessary* to get as many men as possible into the firing line, the following would have to be resorted to. Deploy the leading company as usual. As soon as it has reached the group formation, deploy the second company; as soon as it reaches the group line deploy the third company; the major going into action with the third company. The fire line in this instance would be three deep, separated by from 10 to 20 paces. The first and second line do the fighting, the third line being held in reserve. To facilitate the advance the second line should open a heavy fire, under cover of which the first line should rush as far as possible; the first line takes up the fire, and the second and third lines advance into their new positions. This continues until such time as an assault can be attempted. Previous to the assault, however, when the first can no longer advance unaided, both the second and third lines should be advanced to the first. This agrees with what Sir Lumley Graham says: "For the front or 'firing line,' the only formation, both in attack and defense, which meets these requirements, is a line of small sections extended in single rank, which from being at first very open becomes more and more dense as the antagonists come to close quarters, attaining at last almost the consistency of a line in close order." Having considered the most necessary manœuvres for the battalion, what other means may be necessary to change its direction and fronts? Such a battalion as this occupies but little space, and it can be massed, when not too near the enemy, into a very small compass. Closed in column of companies, its direction can be easily changed by wheels or by flank movements. To change fronts, by a flank movement followed by a file to the left or right. To pass obstacles, by a movement to the rear and left or right of any section or sections, company or companies. The deployment of the closed column will have to be performed as circumstances may dictate, but

for all such manœuvres the present style of tactics will suffice. In all movements a battalion is a battalion whether composed of three companies as herein advocated, or up to ten companies as provided for by Upton's tactics. If possible, all ployments and deployments should be on the centre company or battalion, as the men will have less marching and countermarching.

The Regiment or the Naval Brigade.

The regiment or the naval brigade is the fourth combination of three, and as far as infantry is concerned, no further combinations will be considered at present. Three battalions of three companies each go to make up the regiment or naval brigade. Remember, however, that we are now only considering the main body, and not the adjuncts necessary to the brigade. In addition to the battalion officers, there should be one assistant adjutant-general, one assistant commissary, one aide to colonel or chief of brigade, one staff doctor, and one colonel or chief of brigade. All evolutions for the battalion given in Upton can be performed by this body with the exception of such as require a movement by fours, and in place thereof the face or the wheel by groups will have to be used. These movements will be in close order. Movements in interval order can also be executed. Deployments into battle action will be best performed by one battalion at a time (and still better by one company at a time), in one line or three. If necessary, the whole brigade can be deployed; but it is well to have a sufficient number to support the firing line, as, to quote another's words, "the firing line has to fight out the battle through all its stages to the very conclusion, being supported in doing so by the troops in close order." Let us consider for a moment a brigade drawn up by battalions in columns of companies, and that it had been determined to attack the enemy's position by a direct attack on the centre, or by simultaneous attacks on the flanks. To commence the centre attack, the centre battalion would be deployed as already described, the right and left battalions being held in readiness for the final assault. Before that time, these two battalions should be deployed so as to cover the flanks of the centre battalion to some extent, and their advance so regulated as to join forces close behind the centre battalion at the moment of assault.

Should the attack be simultaneous on the centre and the flanks, the right and left battalions would have to be manœuvred so as to com-

mand the left and right flanks of the enemy. The advances would also have to be made with some degree of dependence upon each other, so as to assault as nearly at the same time as possible. Should neither of these attacks be practicable, the centre battalion could attack as before; and as soon as they had succeeded in silencing the enemy's fire to some extent, the remaining battalions could attempt the assault. In this last it is to be presumed that the loss would be much heavier from the fact of having crossed the zone of fire in a compact mass. There is one evolution that should not be attempted, and that is, forming a square or rallying by companies to resist cavalry. Rather receive such an attack in echelon of companies, with a section from each company deployed as skirmishers, if only one battalion is engaged; if the brigade is threatened, form line of battle with centre battalion, deploy centre company thereof, form right and left battalions in echelon of companies on respective flanks of centre battalion (see Plate VI.). The blocks show the companies of the centre battalion in line of battle; the dots, the centre company in firing line; the right and left wings in echelon of companies. The arrows show the positions of cavalry. *A* shows movement of left wing with cavalry at $A \downarrow$. *B* shows the movements of same wing with cavalry at $B \downarrow$. The left wing either moving up to B^1, B^2, B^3, if there is time, or facing about and making a half wheel previous to delivering fire. The arrows on the battle line show the direction of movement.

The battalions are now so situated that every rifle can be used against the approaching cavalry. The battle line will meet the first charge of the cavalry, and if armed with magazine rifles will do it much damage. The battalions are in such a position that, should the cavalry change its original plan and attempt a flank movement, they could by an *advance* movement change front on the advancing enemy and thoroughly protect both flanks. This formation is favored because it allows of the use of every rifle, because every man on the defensive has a chance to see what the enemy is about to do and cannot be taken unawares, and because it allows, by a sudden change of front, a chance of enfilading the attacking party.

In concluding these remarks on infantry as affected by the factor three, I would like to quote a few words from some authorities in support of my position.

From Sir Lumley Graham's work:

"The formation of infantry for battle must be such as to favor to

the utmost the effect of its own fire, and to minimize the damage done by the enemy."

"The comparatively loose formations necessary in the present day render supervision and control on the part of superiors more difficult. Tactical dispositions will again do something to remedy this evil, but thorough discipline and training will do more, contributing, as they will, to the complete maintenance of the chain of responsibility from the commander-in-chief right down to the leader of the smallest squads in the fighting line."

"Continual practice must be had to enable one to take advantage of the ideas taught."

From Upton: "The want of a system whereby the information and experience acquired in one arm of the service may be made available in the others has long been felt in the army" [navy]. "To make the assimilation as perfect as possible, many changes have been made in the infantry tactics, the reasons for which will appear upon referring to the corresponding movements in the artillery and cavalry" [boats].

From an article written by Captain A. P. du Sonich: "Notwithstanding all the perfections in arms that infantry can show, the cannon will remain the regulator of the fight. It will force masses to deploy, and it is only when these masses are transformed into thin but compact lines that the rifle will show its efficiency."

From "Regulations for Austrian Artillery," by changing a few words: "As a principle, all movements in advance are made in the shape of a fan, on the centre; it is only deployed in one direction unless the ground requires it. The changes of front are executed on a battery [company] designated, most often on the centre."

This ends the consideration of infantry for the time being; enough has been said to show that the plan will work, and that it simplifies all movements. I shall next consider this tactical unit in relation to artillery, boats, and ships.

II.—Artillery.

In organizing the artillery battalion, the size of the company should be the same as in the infantry battalion, viz., 54 privates, 9 non-commissioned officers, 1 captain, and 2 lieutenants. The piece with the limber should be provided with a double drag rope, and the centre and left sections should man it, the right section acting as skirmishers or infantry support if necessary (see Plate VII.). This would give a

sufficient number to drag the piece over almost any obstruction that might offer, and at the same time assuring a number capable of making a desperate resistance against capture. Should the march be over easy ground for a short distance, and extra artillery be necessary, the supply could be doubled, the centre section taking one piece, the left the second piece, and the right again acting as infantry support (see Plate VIII.).

On the march the right could relieve the centre at some convenient halt, and then the centre the left. In moving down hill, numbers 8 and 9 man the short drag rope. The tactics would be the same as for infantry. The "company" would comprise the same privates and officers, and the only change to be made would be in distances when marching in column and battery front. A battery should consist of three companies, corresponding to a battalion, and should be subject to the same orders and drills. In the arrangement of this battery it is desired to keep the formation of the three system as perfect as possible. The arrangement of the sections should be such that one section should always work together, be it at the drag rope, or be it in use as infantry support.

The sections used as infantry supports can be deployed as skirmishers on the flanks and in front if desired. In action these sections could be used as skirmishers on either flank of battery position. In working the gun, if a single piece to a company, the centre section would work the gun, the left and right sections being used as infantry. If two pieces to a company, the centre and left would handle a piece each; the right would be as infantry. In working the section the three groups would have specified duties. The left group would serve the piece, the centre group would act as ammunition passers, the right group as guards for limber; both the centre and right groups would run the limber to cover at the order, "In action." In case only one gun was used, as soon as the limber was safe to the rear the left section would be marched under cover a short distance from the gun. If skirmishers had to be deployed to resist a threatened attack, both the left and right sections could be used as such. On the drag rope the left group or groups are nearest to and around the gun, the right being at the end. The commands for the company would suffice for the one or two pieces. The commands for the battery would be similar to those for the battalion. "Companies right wheel" would wheel one or two pieces, as the case might be. "To the right, march," would wheel each piece to the right, forming a column of

single pieces; "to the left, front into line" would bring it from column to battery front; and since there would always be a right and left to every centre, each working as a single and separate organization though incorporate in a larger one, there should be no disorder, so long as the officers kept their wits about them and realized that when they are on the right they become the right company or battalion, as the case may be, and when they are on the left they become the left of the organization. The centre is always the centre; the right may become the left by giving the order, "Piece right (or left) about, march." The effort is to simplify the routine of drill and cause a few manœuvres to do for the many now in existence. As quoted once before, "the changes of front should be executed on a battery [or piece can be substituted] designated, most often on the centre," and in the same regulations we find "artillery is always supposed to be supported by infantry or cavalry." By the arrangement of sections as given in the preceding pages, the infantry support is provided in the battery itself, so that there need be no diminution of the strength of the infantry by assigning any of it to the defense of the artillery.

It will be noticed that in all formations on the march, the infantry section marches ahead of the men on the drag rope, the reason for this being to have them ready to deploy in case of need. On the march, in column, the section of the leading piece deploys on the centre group forward. The section of centre piece wheels to the right and deploys in same manner, and on arriving at a certain distance from column, changes direction by the left flank. The section of rear piece wheels to the left and deploys on left group forward, and in turn changes direction by the right flank. Thus a line of skirmishers will be formed well in front and on both flanks, while the rear is sufficiently covered to prevent surprise from that quarter.

In marching by battery front, the sections can be deployed forward and on both flanks if necessary. If the order should be "To the right, march," the pieces would wheel to the right, and the infantry section change direction by the right flank, thus keeping abreast of the pieces. If danger should be suspected and it is desired to deploy the infantry sections in the direction of the march, the order, "Battery, halt, fire to the front, in battery," should be given, and at the same time the order for the deployment of the infantry should be such as to deploy the left section on the right group, the centre on the centre group, and the right section on the left group. The pieces being "in battery," the section not working the piece immediately form

as infantry support in readiness to reinforce the firing line. The piece should not "limber up" until the firing line has advanced sufficiently far to show the non-existence of danger, or it becomes apparent that the command must retreat. If a halt is made for a meal, the firing line should be relieved by the section not working the piece as soon as it has finished its meal.

III.—Boats.

In exercise with boats there should be allowed one section to one boat's crew, and one company to three boat's crews. A section in manning boats will then have twelve rowers and six sitters, or if a piece of artillery is carried in the boat, these sitters would serve the piece. For boat exercise the captain of the company will be in the centre boat, the first lieutenant in the right boat when advancing, and the second lieutenant in the other boat. The company can be drilled as a squadron in all necessary evolutions. By combining three companies or nine boats the fleet is formed, having a van, centre, and rear, each composed of three boats. This fleet can be exercised in all tactics now applicable to boats, with a few alterations.

IV.—Naval Tactics.

In the discussion of Commander Taylor's paper on Naval Tactics, published in No. 37, Naval Institute Proceedings, on page 165, I took a fleet of nine vessels, as opposed to Commander Taylor's nine. These were arranged in cruising order, as I called it, and were formed as shown in Plate IX.; the advantage claimed for this formation being that there is no ahead and astern line, consequently less danger of collision, and the system of three is continually maintained. The centre ship is still kept as the leader of each squadron (unit), the senior in command being in the centre ship of the centre unit. On his vessel all movements could be made without his vessel being withdrawn from the squadron to which it belongs. For instance, desiring to form double column on the centre, the double column is formed on the right and left vessels of his squadron, the right and left wings being brought into position astern of those vessels. His movements are still coincident with those of his squadron, but every vessel is easily seen from the senior officer's ship, and the system of threes is still maintained. (See Plate X.)

From this formation any movement can be made. If desired to form line abeam, eight points to starboard, each vessel of the right

wing would change direction eight points to starboard; the centre would wheel eight points to starboard on the right vessel of that squadron as pivot; the left wing would continue ahead, full speed, until centre squadron was well uncovered, and then eight points to starboard and forward into line. The numbers are used so as to show that inversion takes place in the left squadron. Had the order been line abeam, eight points to port, the inversion would have taken place in the right squadron. (See Plate XI.)

An objection may be made to this that the vessels in the left squadron have been, as it were, transposed. True; but does that make any difference so long as there are three vessels in the squadron? A captain can command as well on the right as on the left. The formation which it is desired should be flexible is thus shown to be so. Again, in movements made in this way the ships remain the same distance apart, all turn to starboard at the same time, and there is no successive formation giving a possibility of accident. The successive formation is liable to accident in such a case as this: if while performing this evolution (left wing changing course to starboard one by one so as to bring No. 7 in its proper numerical place), the leading vessel should by accident starboard the helm, then quickly port it, the centre vessel, approaching at full speed, would have either to change its course or ram the leading vessel. The last would most likely be the case on account of the two changes of helm of leading vessel. This indecision on part of the leading vessel would also naturally react on the rear vessel, and so there would be three vessels out of position, all on account of a mistake possibly made by the man at the wheel of the leading vessel. In performing the evolution as given in the diagram, on the signal being hauled down by flagship of squadron, all vessels port (or starboard) their helms at the same time. If now one vessel puts its helm the wrong way it only inconveniences itself. Being in line abeam, column of squadrons can be formed right or left in front, on any squadron desired. If cruising in squadron only, the centre vessel would lead, the right and left being in double echelon on the centre vessel. I think any evolution can be performed and the system of three be kept intact.

In all that has been said it has been the endeavor to preserve three as the factor of each and every branch of tactics. There are objections, of course, to such a system, one being that a complete revolution has been attempted. It may or may not be a successful one, but that can be said of all attempted changes. The subject has been only generally treated, as it is not the intention to write a tactics.

DISCUSSION.

Lieutenant-Colonel H. S. HAWKINS, U. S. A.*—I have read with much pleasure Lieutenant Mahan's paper which shows research and careful study of the very important subject of modern infantry tactics. In submitting the "opinions and criticisms" invited by the U. S. Naval Institute, I must apologize for unavoidable allusion to work of my own in the same direction.

I agree with every word quoted from Colonel Macdonald's lecture, and I can confirm the truth of his assertion that "men moving with an interval between them can be drilled, and have been drilled, to as great steadiness and accuracy of movement as they have ever been brought to in close files."

Lieutenant Mahan's proposed deployments of the group of six are very similar to the deployments of Upton's group of eight or set of fours, and I do not see that there is a marked gain in celerity. The principal criticism that I make of the proposed unit of three is the same as the objection to the present tactical unit of four, viz. that it necessitates counting off, which is practically the same whether the counting be done by the men themselves or by the lieutenant, who, according to Lieutenant Mahan's plan, counts off one, two, three; one, two, three; one, two, three. Indeed, the counting by the men is more rapid. But I would do away with counting off altogether.

In a system of infantry drill which I have prepared the men fall in in four ranks, thus:

This is called the *Column of route*, being that used for marches. The first rank is always that which is farthest from the file closers, who may be ordered to either flank of the column. The second rank is 12 inches from the first rank. The third rank is 12 inches from the second rank. The fourth rank is 12 inches from the third rank.

Each man in the first rank is 56 inches from the next preceding man in his own rank. Each man in the second rank is directly opposite an interval in the first rank. Each man in the third rank is abreast of the corresponding man in the first rank. Each man in the fourth rank is abreast of the corresponding man in the second rank. Now face the column to the left (or right) to form line. This is called the *Normal line*. The first rank is that which is in front, no matter which way the line faces. If it faces toward the file closers they pass through.

Each man in the first rank is 46 inches from the next man on his right or left. Each man in the second rank is, as before, directly opposite an interval in the first rank. The men in the third and fourth ranks simply cover their file leaders. Now close files to the front; the result is this:

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This is called *Line of two ranks.*

There is an interval of 12 inches between each two files composed of front and rear rank. The rear rank men take a side step to the right to fire through the intervals.

All movements are habitually made in *normal line* or in *column of route*, and with as much of personal comfort in one as in the other. There is no counting off. A man falls in and cannot help *seeing* what rank he is in.

To illustrate this give these three commands: *Fall in; Left face; Stack arms.* In all other systems the men must be numbered to stack arms. In this system each man *in the first rank* makes the stack, seizing the piece of the man in the second rank on his left rear with his left hand; each man in the third rank steps forward to help his file leader make the stack; the pieces in the fourth rank are loose pieces.

When desirable the men form in *column of route* with intervals of 32 inches instead of 56 inches, so that upon facing to the front and forming *line of two ranks* the men are elbow to elbow.

A company being in *normal line* the captain sends forward the first rank, *already deployed*, to open the fight; or he uses two or three ranks; or he may develop the whole company. Then again he may detach the first platoon under a lieutenant who can use it precisely as he would a full company, the other platoon being used as the main reserve.

Being in *column of route* the captain uses one or more ranks or the whole company, as circumstances require.

The deployments from *normal line* are made forward or by the flanks; to the right or to the left, or to both right and left.

No matter in what way the deployments are made, at least one entire rank can instantly open fire while the others are taking position.

The deployments from *column of route* are equally rapid.

I tried the following experiment in the presence of General Terry and General McCook, Colonel of the 6th Infantry, at Fort Leavenworth:

One hundred men were taken promiscuously from the infantry companies and told to distribute themselves like a lot of tired men will do while resting on a dusty road, of course breaking up all formation. They were told that three commands would be given, viz.: *Fall in; Deploy as skirmishers;* and *Commence firing.* They were timed by the watch. The execution of all three commands took one minute and five seconds, and these hundred men were deployed systematically nearly one hundred yards to the front, firing from shelter. With men accustomed to the drill this time can be diminished one third.

I claim that my men could be at effective work before a company of equal size could count off.

It seems to me that the simplicity of the drill and the absence of all numbering of the men are features peculiarly suited to the notions of sailors who may

be required to fight on land. Jumping ashore from the boats, the command is given to *Fall in.* The very next command may be to *Deploy as skirmishers*, or to detach one or more ranks to open the attack, without losing time to count off or to divide into sections. The act of falling in practically divides the force, whether small or large, into four sections ready for use without further ado.

The rushes which Lieutenant Mahan speaks of are made by alternate ranks. The fire of each rank is controlled by its own chief, and all may be brought to bear upon one objective by direction of the chief of the *firing line.*

In all formations, whether of line or of column, at full distance or closed in mass, the men may be ordered to lie down without disturbing the formation.

But this paper is becoming longer than I intended and may prove too great a tax upon your patience.

Lieutenant D. H. MAHAN.—The counting off by threes is not necessarily required in the section, and I think that my company can form quite as readily when landing from boats, when it is considered that a section is seated in a boat in regular order and is actually forming as the men jump over the bow ashore. They can be trained to take their position in two ranks quite as readily as in four.

The section being in a boat, the order is given, "Land, deploy." The first group moves off to the right, the second advances, and the third to the left, without further orders.

I agree with Colonel Hawkins in desiring to avoid counting off, and for that reason I have given my section only nine front; as with careful training and an average amount of sense in the men, they can by looking to the right and left easily determine their position.

In regard to stacking arms, the front-rank leader makes the stack, using the pieces on either side with his own; the rear rank lays on loose pieces. There is no moving, no reaching to the rear, and all the pieces of a group are in the same stack.

In opening the fight, the leading section can be deployed first, then the centre section, and then the remaining section; or the whole company can be deployed.

One or two sections can be detached and each used as a company, the other sections or section being in reserve.

For example, of these two columns marching by the flank along a narrow road, which is easier, to advance skirmishers from a column in which every other man has to step out of ranks and the rear man has to run the whole length of the company, or to deploy the leading section? With Colonel Hawkins' "line of two ranks" marching by the flank, and the order, "1st rank deploy" be given, numbers 1, 3, 5, 7, up to 25 have to step out of ranks, run to the head of column and deploy. With the plan under discussion, the order "Right section to the right (or left), deploy," is given, and only the men at the head of the column deploy. I do not think in this case his rank can open fire as quickly as mine without danger to those near them.

Never having had an opportunity to practice men in my drill (such opportu-

nities being rare), I cannot say how long it would take to deploy as Colonel Hawkins describes, but I think with practice I could drill a company to pull themselves ashore and land and deploy in fully as quick time. I incline to my rushes, since I can keep up a continuous fire without as much danger to my men as in the case where rank has to pass through rank.

I am sorry not to have seen more of Colonel Hawkins' plan, as I am fighting in the dark in regard to many points. I can see no system of association in the movements described, and consequently no rallying or assembling system. A jump is made from the man to the company. It seems as if the men are left too much to themselves in the fire line; in fact, the sixth point in my article is entirely disregarded, viz.: "In addition, a thorough command, a development of comradeship in small groups, giving rallying power to small parties. This is the *essence* of restoring order in large bodies suffering from disintegration during the conflict."

Lieutenant W. F. FULLAM, U. S. N.—There are two extremes to be avoided in considering the question of tactics: first, an obstinate and unreasonable conservatism which resists all change, no matter how necessary; second, an inordinate desire for change for the mere sake of change, with no accompanying benefit or gain in principle. Both of these extremes are dangerous—the latter more so than the former, perhaps, since ill-timed revolutions always create a great deal of unnecessary trouble. There is, however, a safe, level-headed position which should always be sought for, characterized by a perfect readiness to accept amendments whenever anything is to be gained by so doing, and a firm resistance to changes for which no good reason can be advanced.

The scheme devised by Lieutenant Mahan is most ingenious, interesting, and instructive, and the discussion of such a plan is sure to be beneficial, provided criticisms are invited and encouraged.

Lieutenant Mahan gives no reason for changing the unit from four to three, and I am not enough of a tactician to know whether a good reason exists or not. I can see none, however. Major Livermore, U. S. Army, in the discussion of the Prize Essay, says: "It is desirable to organize the regiments with twelve companies, not so much for the sake of having *three* battalions to a regiment as for the sake of having *four* companies to a battalion, and in time of war it would be well to add another battalion so as to make sixteen companies to a regiment. It would be well also to group the higher and lower units in *fours, and all European nations are coming to this conclusion.*" This is rather strong evidence of a tendency toward combinations of four instead of three.

There would appear to be one danger in this plan of organizing everything by threes—that a plan of deployment and manœuvres may be adopted with a single idea pervading it, so that the plan may not work well when other conditions of organization may necessarily exist. In other words, any system of deployment and manœuvring in battle should be so general as to be equally applicable to companies of any size, composed of two, three, or any number of sections or platoons; to battalions composed of three or any other number of companies, and to regiments or brigades composed of any number of battalions. This requirement must be fulfilled in any system adopted for the

Navy, since all ships' battalions cannot be of the same size or be composed of the same number of companies. Two, three, five, or ten ships may land their battalions, thus forming regiments of different sizes, to each of which our tactics must be equally applicable. However ingenious the system of threes may be, therefore, it is dangerous and narrow unless it can be easily applied to all these different circumstances of organization. Major Livermore, for instance, tells us that "whatever system may be adopted in the Army, *it will be so flexible* as to be fully applicable to any grouping that may be required from time to time, for the organizations will seldom be complete, and the fractions of several units will be often united."

There seems to be a wide diversity of opinion regarding the best size for the companies in a ship's battalion, but the majority seem to think that 36 men is the proper number. If the battalion is to be built up from the gun divisions, 36 men will require less transfers, since the guns of modern ships are rather detached from each other, and the divisions will approximate more nearly to that number than to any other—more nearly than to 63, as Lieutenant Mahan proposes. The number in the different divisions on board the Boston, for instance, are: 1st Div., 35; 2d Div., 35; 3d Div., 32; 4th Div., 25; and Marine Guard, 40. By transferring a few men from the Powder and Navigator's Divisions these five companies can be filled and equalized. A front of 16 men is a convenient front to handle, particularly in a street. And right here it may be proper to say that mob and street fighting, or service in the streets of cities, is that which naval battalions are most likely to perform, and therefore more attention should be paid to it. We talk a great deal in the Navy about skirmishers and battles, but history shows very few instances of real skirmishing on the part of our naval forces, and more cases of landing for service in the streets of cities. To organize companies of 63 men would probably be very troublesome in many cases on board ship. It is seldom that the Marine Guard contains that number of men, and it is certain that the Boston's battalion would not be as efficient if organized in companies of 63 men, since the divisions would be quite broken up. Right here, then, we see that the system of threes will not work well, for instead of three sections or platoons to a company, it is more advisable to have two of eight men front forming a group of sixteen men, and it is a most convenient size for street service. In case a division on board ship contains more than 36 men, I see no reason why its company should not be increased by one group or two. If we are really going to get rid of parade principles, stiffness, and cast-iron rules that interfere with flexibility, why should all companies in the Navy be of exactly the same size? A company may land in three boats as well as in two.

As regards orders, I think Lieutenant Mahan's changes are in many cases quite unnecessary—mere changes with no gain whatever in brevity or principle. For instance, why say "section" instead of "platoon"? The latter is a good term, an old one which we all understand—every sailor is familiar with it. "To the right march" is not as good as "Right flank march," and "Sections right march" is little better than "Platoons right wheel march"—there is not gain enough in these changes to make them advisable. A change of

tactics will cause trouble enough without compelling everybody to learn a new language. To be practical and assist every officer and man to learn a new system quickly, we should retain such familiar and expressive tactical words as "platoon," "flank," and "wheel" whenever they will apply.

Compare Lieutenant Mahan's orders for deploying a company with the orders given in Upton.

Mahan.—Captain commands:—"On the centre section, for battle action, double time, march" (10 words). Afterward each lieutenant and the captain command:—"On the centre group, for battle action, double time, march" (10 words). Finally the captain commands "deploy," making in all 21 words to deploy a company. Indeed, as the second set of orders is given by *each of three different officers to each of three different sections* it ought to be counted three times, which would make 41 words. But no matter—count it once.

Upton.—Captain commands:—(1) As skirmishers, (2) On the centre four take intervals, (3) Double time, (4) March (11 words); and afterward "deploy" —total 12 words to deploy a company, while Lieutenant Mahan uses at least 21 words, or nearly twice as many. Besides, in Upton all the orders are given by the captain, which is far better than the repetition necessary in Lieutenant Mahan's method.

The principle of the deployment is essentially the same in the two cases, except that Upton's is simpler and more direct in not separating the company into sections or platoons. In other words, we have a complete change of orders, and more of them, to accomplish the same identical result. Surely such changes as these are not in the direction of greater simplicity, do not gain anything in principle, and ought to be resisted, since they would only cause unnecessary trouble to every officer and man in the acquirement of a new system of tactics.

Furthermore, in the deployment of a company, as shown in Plate V., more time would be required and every man, except those in the centre group, would probably have farther to go than in the same method of deployment provided for in par. 282, Upton's Tactics. This may be seen by drawing a straight line from each group in the company (Plate V.) to its position in the line of groups —this straight line representing very nearly the path taken by the group in deploying by Upton. Now trace in Plate V. the path of each group by Lieutenant Mahan's method, and it will be seen that in nearly every case his group travels over two sides of a triangle of which the third side (and therefore the shorter distance) is the path by Upton. Lieutenant Mahan's system of deployment is, therefore, inferior to Upton's in requiring more orders, more time, and more travel. It is all due to the fact that Upton wisely causes the fours, or groups, to diverge and take intervals *at once*, while Lieutenant Mahan first deploys the sections and then the groups, which is quite unnecessary in such a small company. Here, therefore, is one instance where the tendency to follow up the one idea of dividing everything into threes fails to result in that "simplification of formations, giving the utmost freedom of movement," etc., mentioned in Lieutenant Mahan's *Point No.* 1, and violates entirely his *Point No.* 5, "The adjustment of all details so as to give *speed of movement* while

saving the troops from *all unnecessary fatigue.*" Nor does Lieutenant Mahan's method attain *as quickly* as Upton the principle quoted from the Regulations of the Austrian Artillery, "all movements in advance are made in the shape of a fan on the centre."

Lieutenant Mahan gives a method for "sudden deployment in case of a surprise," and provides that—"At this order each leader of a unit will start to right, left, or forward, as the case may be, followed by his two flanking men . . . . . Proper shelter is the first thing a unit leader should look for in case of a deployment by reason of a surprise." To provide for a special deployment in case of surprise is to acknowledge the weakness of the ordinary method. Better consider that every case may be a surprise, if we are to be practical in the future and do away with parade drills. There is probably one system of taking intervals that is best and quickest, and that system should be used at all times. The men should not be taught to *mistrust* the ordinary method of deployments, but rather to *have faith in it* at all times and to observe it strictly. Their steadiness may then "surprise" the enemy. To use Lieutenant Mahan's quotation: "One should not attempt *artificial combinations*, but rather spend the time in *repeating* the *simple routine* hundreds and thousands of times. Thus, and thus only, can you feel sure that what you require will be done before the enemy." In other words, teach the *simplest routine* and no other; repeat it hundreds and thousands of times, and the men will be ready for every "surprise," and will not be demoralized when a sudden emergency arises. I believe that if "each leader of a unit starts off to right, left, or forward," looking for "proper shelter the *first thing*," many of them will make for the same "proper shelter," confusion and disorder will be the result, and a scramble will ensue. Even if the units keep together (which is doubtful under such instructions), the *groups* would be entirely destroyed by teaching the *units* to "start off and look for proper shelter the first thing." *It is a fatal mistake to teach men to seek shelter until after the deployment is complete*, and it is more necessary to preserve the groups in case of surprise than at any other time. A company can take intervals by Upton's Tactics in less than 30 seconds. I have, this very morning, deployed my company of 36 blue jackets forward on the centre four by Upton in 15 seconds. This is quicker than Lieutenant Mahan can do it by his ordinary method of first separating into platoons, and by cautioning the men to seek cover *after the groups get their intervals, thus insuring a proper length of line*, a surprise will be met by Upton far better than by Lieutenant Mahan's "surprise deployment." To sum up, the surprise deployment is dangerous in not insisting upon the preservation of the groups and a careful taking of intervals necessary to cover the front and prevent being flanked, while Upton's method would be quite quick enough, would preserve the groups or fours intact, and realize the principles of Lieutenant Mahan's *Point No.* 6—"A thorough command, a development of comradeship in small groups, giving rallying power to small parties. This is the essence of restoring order in large bodies suffering from disintegration during the conflict." Would not the surprise deployment prevent "a thorough command" and "rallying power" too, and cause "disintegration" *before* the "conflict"?

In the formation of the company it is not easy to see how any counting off is done away with, as Lieutenant Mahan claims. On the contrary it would appear that, in reality, there is quite as much counting off, if not more, by Lieutenant Mahan's method, the only difference being that the lieutenants do the counting instead of the men themselves—a change by which no principle is gained, while time is lost. Lieutenant Mahan appears to contradict himself on this point. He says "the lieutenants divide the company into three sections, *thus doing away with counting off*"; but in the next sentence he adds: "the first lieutenant *counts* from the right of the company nine and there indicates the left of the right section; the second lieutenant now takes up the *count*, and *counting* nine shows the division between the centre and left sections," and farther along we find—"*In counting off the sections the lieutenants count one, two, three; one, two, three; one, two, three.*" After asserting that counting off is done away with, Lieutenant Mahan uses the words "count" and "counting" five times, and in the last sentence quoted above he shows that the counting off is thorough and complete. Again he says, "the men have no numbers to remember," and afterwards he adds, "No. 2 is always centre man." Evidently, then, every No. 2 must be designated and must remember that he *is* No. 2, or centre man; and each of the other two men of the same unit must know and remember that he is *not* No. 2—or, in other words, that he *is* either No. 1 or No. 3, and if he is not sure *which* he will not know whether his unit leader *is on his right hand or his left.* In short, Lieutenant Mahan might just as well give the order "count threes" and be done with it, and it must be perfectly plain that it will take more time to form his company than by Upton. In one case the *men* count fours; in the other case the *lieutenants* count threes. In one case the first sergeant forms the company; in the other case it requires the first sergeant and two lieutenants to do it. In one case the company is divided into *two* platoons; in the other case into *three* sections. In one case the platoons do not embarrass the deployment as skirmishers forward on the centre, but we may deploy without dividing into platoons; in the other case the division into three sections is absolutely necessary and it delays the deployment.

Treating of the battalion, Lieutenant Mahan gives a method of deploying the whole battalion in "a single line of skirmishers." The orders by this method would be as follows: By the colonel—1. "On the centre company for battle action double time march." (10 words.) By each captain when company interval is attained—(2). "On the centre section for battle action double time march." (10 words.) By each captain and each lieutenant after sections get their intervals—(3). "On the centre group for battle action double time march." (10 words.) And finally each captain commands "deploy," making 31 words. As before, the third set of orders, being given by three separate officers of each company, ought really to be counted three times, which would make 51 words. By Upton the commands are, by the colonel—"As skirmishers on left four (such) company take intervals double time march." (12 words.) Each captain when company interval is attained—"As skirmishers on left (or right) four take intervals double time march," (11 words), and finally each

captain "deploy," making 26 words in all, compared with 31, or 51, by Lieutenant Mahan's method. The principle of the deployment is the same, except that the unnecessary deployment of the sections of each company by Lieutenant Mahan's method requires more time and causes an unnecessary repetition of orders. As in the case of the company, therefore, Upton's deployment of a battalion would be quicker and simpler than Lieutenant Mahan's, and we have another change for the worse, with new orders for an old manœuvre.

It is certain that in no modern system will a battalion, operating alone, ever be deployed in a single line of skirmishers, but always in three lines—a firing line, a supporting line, and a reserve. It is even a question as to whether the battalions in the regiment should not each form its own firing, supporting, and reserve line, thus preventing the mixing up of battalions as far as possible. This is a matter for discussion, however.

Lieutenant Mahan deploys the battalion into three lines from column of companies, and gives a method of manœuvring in action. In this disposition of the battalion all three companies are deployed, even the reserve, and in three lines "separated by from 10 to 20 paces." It is evident that these three lines are so close together that they are all subjected to the fire of modern weapons, while the reserve, at least, is powerless to contribute to the fire. All the men might as well be in the same line as far as protection is concerned. Lieutenant Mahan says the first two lines do the fighting by alternately rushing and passing each other. This would seem to be a dangerous expedient. A man would hardly feel happy with his friends firing in rear of him, and should he not advance in a straight line, but zig-zag to get cover, he would be as much in danger from friends in rear as from foes in front. In this attempted inter-passing of two lines in the smoke and noise of a fight it is probable that there would be much confusion and the fire of both lines would be seriously interfered with. Volley firing, which we are told must be the essence of any modern system, would hardly be possible in this case. In every modern system that I have been able to look up, the supporting line is held some distance in rear, gradually feeding men into the firing line, these men always attaching themselves to the groups of the firing line as soon as they reach it. Sometimes entire groups from the supports may be thrown into intervals that may exist. In this way the supports are gradually merged into the firing line, and the different groups, being kept intact, may advance by rushes in echelon and fire by volleys. This would be far better than having two lines alternately rushing through each other; there would be less confusion, and less danger from friends.

But it is in the matter of the reserve that Lieutenant Mahan appears to have made a fatal mistake. In the first place he *deploys* his reserve, whereas in every modern system *the reserve will be kept massed under cover until needed.* In the second place he deploys it so near the firing line (20 paces) that it cannot move by the flank to meet a turning movement; it cannot be assembled or moved to the rear, in fact it cannot be manœuvred at all except "under the terrible fire of modern weapons," in open violation of Point No. 4. In short, by this disposition of the reserve, Lieutenant Mahan throws away all chance of

properly meeting a flank attack, or of making a flank attack himself. But flank attacks, and a little strategy, are ten times more necessary now than ever before, and men will take more delight in making them than in attacking in front. Lord Wolseley says: "In future, owing to the long range of all arms, attacks upon the centre must be very exceptional; *the flanks will be the points to aim at.*" Now suppose Lieutenant Mahan's opponent throws his supports into his firing line, which gives him as many rifles as Lieutenant Mahan has engaged, and then, keeping up a hot fire, sends a portion of his reserve to make a detour and take Lieutenant Mahan in the flank, what will be the result? If Lieutenant Mahan's reserves get up on their feet most of them will be obliged to run the gauntlet along the whole line of fire, and few would probably arrive to meet the attack. *The side which most surely retains the means of meeting or making flank attacks will be most apt to win.* In this treatment of the three lines for a battalion, Lieutenant Mahan is hardly justified in quoting as his authority Sir Lumley Graham's principle: "The formation of infantry for battle must be such as to *favor* to the utmost the effect of its own fire, and to *minimize* the damage done by the enemy." It would seem, on the contrary, that three lines so deployed would *minimise* "to the utmost the effect of their own fire," and *favor* "the damage done by the enemy."

Lieutenant Mahan's propositions to do away with a fixed front rank and to use "to the rear" and "about face" instead of the wheel about by groups, are all most excellent. Time would always be saved by such changes, and officers would not feel a pang (as all are apt to do now) whenever they get their fours inverted. The method of deployment to the rear is new and certainly a most excellent change. It might be very necessary to deploy suddenly and take up a position in rear of the company or battalion. At the order "to the rear," or "about face," the guides could step back and allow file closers to pass through and take position in rear. All these changes should be recognized as gaining time and conducing to mobility and freedom of movement.

To sum up:

1. The reason, or necessity, for changing from units of four and groups of eight to units of three and groups of six should be carefully considered, that the rule of multiplying and dividing everything by three may not result in loss of flexibility.

2. Up to and including the battalion, it is not plain that Lieutenant Mahan's methods are always founded firmly upon the excellent *points* and authorities he cites, but that many of these points and authorities may be turned against his tactics.

3. With deployments similar in principle, but often less simple than Upton's, we have an entirely new system of orders—mere changes in words.

4. In the one most essential feature of modern tactics, the deployment and manœuvring of a battalion in three lines, we find that Lieutenant Mahan's methods fail entirely to meet modern requirements and violate his own points. In this respect, the most important of all, his plan is not so good nor so modern as the plan provided for in Art. 354, Upton's Tactics, where one half the battalion is deployed in the firing line, about one third in the supporting line 300

yards in rear, and the remainder held in reserve 400 yards in rear of the supports. Upton here agrees very nearly with Lord Wolseley's rule of one half, one third, and one sixth for the three lines.

These criticisms and opinions are submitted with all due humility, with no disposition to resist well considered changes, and with the firm belief that the board of army officers now sitting will solve successfully the problem of a modern system and give us one that will be flexible and equal to all demands. We certainly should not fall down and worship Upton with the blind, innocent faith with which a Chinaman worships his little wooden god, nor should we be too ready to reject one god for another of the same or worse material but covered with different war paint.

As regards cavalry attacks, Lord Wolseley says: "The formation of battalion squares to resist cavalry may be almost regarded as a thing of the past, for with long-ranging arms of the day, to put your battalion into such a formation would be to give it over to destruction. *Small company squares* or *groups of men* standing together shoulder to shoulder and availing themselves of any hedges, trees, or any other obstacle there may be at hand, *can now hold their own well against any number of cavalry, and very rarely will cavalry be found to charge infantry in line who are armed with the murderous breech-loader.*"

It appears that Lord Wolseley prefers *small* company groups or squares to any other formation, and inclines to the belief that no other special formation is necessary to resist cavalry. The quickest formation would seem to be the best—*the one that will least disturb the particular formation in which the infantry happens to be when attacked.* But Lieutenant Mahan, doing away with company squares or the resistance by groups, which would be quick and effective (according to Lord Wolseley), gives us a long and rather intricate manœuvre which would make it appear that cavalry attacks are very dangerous. With a battalion Lieutenant Mahan forms "echelon of companies and deploys one section of each company as skirmishers," and with the brigade he "forms line of battle with centre battalion, deploys centre company thereof, forms right and left battalions in echelon of companies on respective flanks." In other words, we have both a skirmish line and an echelon formation to resist cavalry. One or the other is certainly unnecessary, and to do both is uselessly to consume time. If skirmishers cannot resist cavalry *alone* they should not be thrown out at all. If they *can resist it* they should be supported instead of wasting time with other manœuvres. Lieutenant Mahan says "the battalions are so situated that every rifle can be used against the approaching cavalry." Can they use their rifles with a skirmish line in their front? Certainly not until the skirmish line is withdrawn or destroyed. Does not the skirmish line thoroughly protect the cavalry from the fire of the battalions? Not only this, *but Lieutenant Mahan cannot use his artillery at all against the cavalry* because of his skirmish line. I cannot see that Lieutenant Mahan improves matters by this method, or secures the "simplification of formations" of Point No. 1. Throwing out a weak and insufficient skirmish line (one company in a brigade), preventing the use of artillery or infantry, is not in accordance with Sir Lumley Graham's advice "to favor to the utmost the effect of our own fire and to minimize the damage done by the enemy."

Instead of these devices to resist cavalry it is probable that simpler ones may be used. If the battalion or brigade is already deployed in proper battle formation—three lines, the supports thrown in to the firing line and rallied by groups firing volleys will meet the attack in front. Our own cavalry and our reserves of infantry and artillery may be used to meet flank attacks—that is what they are for. Surely we cannot change front with our whole force of infantry, or form echelon of companies or battalions if the enemy has infantry at hand, and any good method must suppose the worst—that the enemy has something besides cavalry.

Should infantry not be deployed when the attack comes, but if it is in line, column, or any other formation, send out a sufficient number of companies to meet the attack, or receive it as we stand with volleys from infantry and artillery and send our cavalry to attack in flank. According to Lord Wolseley this will be sufficient, and will prevent a loss of time. If artillery is at hand it might be well to invite cavalry to attack us in order to destroy the enemy's force. Infantry should not be taught, with their present weapons, to *fear cavalry*, by the adoption of such means to resist it; rather impress them with the idea that they are always more than a match for cavalry in whatever formation they may chance to be. If all this manœuvring is necessary to resist *threatened* attacks of cavalry, our enemy could stop our progress completely and keep us everlastingly changing front and forming echelon of companies, by threatening first one flank and then the other, and we would never succeed in getting anywhere.

Lieutenant D. H. MAHAN.—My reason for changing the unit from two or four to three is, that I think four sometimes too large and two too small for a column. Take a country road for instance, such as an army has often to march along; I consider three as a preferable number.

In regard to the danger of this plan having a single idea pervading it, may it not be asked if the single idea does not pervade Upton; that is, his idea of counting off by fours? How could one drill by Upton if it were not for his idea of four which pervades it? His system of fours does not hold throughout, but might it not be better if it did? How many plans does one now have to remember? Lack of space obliged me to leave out many explanations of my plan, and many cuts could not be printed by the Institute which would have shown that it was not so dangerous and narrow as it is supposed to be. In regard to having four companies, I can employ a fourth company with machine guns; this, however, will not interfere with the formation.

On board the Boston, why might not the companies be composed each of two divisions; this would not necessitate a call for men from the powder or navigator's divisions. Combine the first and third divisions—67 men—send five of these to complete the company composed of the second and fourth divisions, and there would be two companies of 62 men each. With a captain and two lieutenants each, the two companies would be better officered and the organization require fewer officers. (There should be two officers to a company of 36 men.) The Boston's companies then should have, under the present organization, eight officers in all; using my system, only six are required. It may be

asked where my third company is to come from. Form the marines in single rank, the sergeants taking the places of the lieutenants; there would be 35 men in all. Again, a front of nine men is none too small for street fighting, and in marching in column of sections there is a complete organization at the head of the column, which can be drilled as a company. The front can be increased to 18 men by obliquing the rear rank to right or left. I think that the assertion that "if the company were composed of 63 men the divisions would be quite broken up" is not verified by my showing above.

I use the word section because a platoon is supposed to be one half of a company; my section is but a section of a company. In the next paragraph complaint is made about orders being too long; here they are considered too short—some people are never satisfied. Again, in quoting orders they should be quoted correctly: the order is "To the right flank march," and not "Right flank march."

In comparing my orders with Upton's, Mr. Fullam should have been generous enough to have also taken one of my short orders, "Deploy," by which I can deploy a company with one word as quickly as Upton can, using twelve words. Counting words in orders is, however, a good deal like splitting straws. Orders are necessary to have work performed; during drill they are used in their entirety, on the field of battle but seldom. Recalling two famous orders used on the field of battle which never appeared in a tactical book, will show how unnecessary any discussion about orders is. "A little more grape, Captain Bragg," was longer, but accomplished the same result as completely as if the order "Load with grape" had been given. "Up, Guards, and at them!" did a thousand times more good than "Rise, charge bayonets, forward, double time, march" would ever do. As far as making one learn a new language is concerned, did not Upton's cause such a change?

In regard to the repetition of orders Mr. Fullam seems to lose sight of the fact that after the company has been deployed in line of sections, I might wish to deploy only one section on account of the nature of the ground over which the company was advancing. This is the time when the lieutenant gives the orders. There is nothing to prevent the captain giving the order for the whole company, but I have provided for the case in which the country might be such that the captain could not possibly see all his command.

Deployments will always be essentially the same in any tactics that may be written, and I fail to see how it is made more difficult by introducing an intermediate step between the company and the group. If Mr. Fullam had read my article carefully he would have seen the object of my developments in Plate V., but, since he wishes to arrive at mathematical precision as to distance travelled, let us take these two cases—a front rank of a group of threes and a front rank of a set of fours: the former deploys on the leader (centre man); the latter on No. 4. Deploy five paces to the front each squad; with mine the men walk 7, 5 and 7, with Upton's 5, 10, 15, 20: $20 - 7 = 13$, a gain for my system of 13 paces, or in other words, deploy both and my men will be each one 13 paces in advance of Upton's. Take now the group of three and the set of fours; the paces are 22 and 25, or I have deployed and advanced three

paces when the others have finished deploying. (This is explained in answer to Mr. Haeseler). Now for the company. I deploy on the centre group of the centre section, the other on the right or left set of fours. (I leave my section development out, as it can be used or not.) I will take my complete company of 54 men, allowing only 48 men to the other. When the latter has deployed, I will have deployed and advanced 70 paces. Now I will deploy the smaller company on the centre skirmisher and my own company; the smaller company will have the advantage of mine by two paces, but increase the smaller company to the same number of men as mine and I will be ahead by 6 paces. The distances have been computed by taking the distances marched by flank skirmishers of each set of men. Credit is not given to the fact that the company can be deployed at once to the group line; it is also forgotten that in a fan opened from the middle the two outer sticks have just one half the distance to go as if it was opened on either outer stick. Not intending to write a tactics, each and every movement that can be made has not been given.

"To provide for a special deployment in case of surprise is to acknowledge the weakness of the ordinary method"; this is a new way of looking at it. It might as well be said, if our present tactics show no deployment in case of surprise, of what use to think of it? I have heard of ambuscades, of surprises, of how men have been shot down as they stood, not having been drilled as to what to do in such a case. Would it not have been well to have had some drill for just such an occasion? It is by this repeated drill that I desire to have my men so trained as to be in no danger of a surprise discomposing them. If they know just what to do when the captain yells "Deploy," are they not better prepared than if habituated to await a longer order, having been drilled to deploy by numbers and also by fours, but no way given in case of surprise? Better to have a little scramble (for shelter), out of which order will come, than to stand huddled like a flock of sheep waiting for some officer to decide which to use, numbers or fours, and, unable to stand the attack, rushing to the rear with no leader and no idea what to do. Mr. Fullam fails to see that my "artificial combination," as he calls it, is only my regular deployment with deployment to sections left out. He says that only by repetition hundreds and thousands of times can these things be learned, yet he says a few lines below, "even if the units keep together (which is doubtful under such instructions)"; or he praises and condemns in the same breath.

Mr. Fullam may say it is a "fatal mistake to teach men to *seek shelter* until after the deployment is complete," but that same teaching has saved many valuable lives in Indian campaigns, and I would rather have my men make the "fatal mistake" and live, than have them stand in military precision to be shot to death waiting for the development to be completed.

How far did Mr. Fullam deploy his company, and how can he make such an assertion as he does, until he has seen some movement tried? Having shown my forward deployments, in which I think I have the advantage over Upton, I will now deploy two companies of 54 men each. If deployed to the left flank I gain 5 paces on the other, for deploying on the centre man of that group one man goes to the right; if deployed to the right flank, on the centre man of

the group I gain 20 paces, as four of my men go to the left flank; if deployed on the centre skirmisher I gain 30 paces, for 28 men go to the left and 25 men to the right; in the other, 34 go to the left and 19 to the right. So while Mr. Fullam has deployed his company I have deployed and advanced my whole line 30 paces.

In Upton there is no leadership in the group and there is no development of comradeship. My surprise development having the centre man as leader, *preserves* instead of *preventing* what I have said in No. 6; and although it may cause orderly dispersion before the conflict, it may save disintegration during the conflict.

Mr. Fullam proposes either to develop his skirmish line two miles or thereabouts from the enemy, or to march his full battalion up to close range. I desire to gradually diminish the size of my target (making the direction and speed of movements somewhat irregular, as required by the Austrian field book), at the same time continuing my system throughout. In the former you go from the "plank of the line or the log of the column" to the individual, while I try to do it gradually and preserve my "comradeship in groups" with "a thorough command throughout."

Had Mr. Fullam read carefully he would have seen that *in no case* do I allow a rank to pass through another, nor does he notice the words necessary in his reference to "even the reserve." Not always do I deploy my reserve, only if necessity calls for it. I can always keep my reserve of one or two sections or companies (as we refer to companies or battalions). I can use either section or group as a reserve, while Upton uses fours from the right or left. Having the centre as reserve, I am in nearer supporting distance to either flank.

To show that there is no interpassing of ranks, I will quote a few of my own words: "The advances when the company is deployed will be by rushes of sections. The centre rushes first, covered by the fire of the right and left sections, followed by both the right and left, or, if the opposing fire is very heavy, by only one section at a time." But the first line is always the first; the second, the second; the third, the third; until "such time when the first can no longer advance unaided." I follow out in this what Sir Lumley Graham says, "the firing line has to fight out the battle through all its stages to the very conclusion, being supported in doing so by the troops in close order." I feel also that I am justified in quoting Sir Lumley Graham, as my advance would not *minimize* their own fire and would not favor the enemy's damage nearly so much as the present system of advance in the skirmish line, in which there is a continual interpassing; Nos. 1 and 3 firing as Nos. 2 and 4 advance and *vice versa*.

In the summing up I would like to say, (1) that the system I have presented has been carefully thought out, that it is not, as Mr. Fullam thinks, but little considered. The plan was conceived several years ago, and was only finally presented when I saw no one else seemed to take sufficient interest in the subject, and so I thought I would start the ball rolling. In marching in column of fours I have many times observed that the file closers have to press into the column, and in the usual but preposterous march round, the column

of threes would work much better in the narrow gangways. I think that my system, if experimented with, would develop an increase of flexibility instead of a loss. (2) My method, I think, more nearly approaches the points I have selected as my guides, than any we have in use, and although my points may be turned against it, they have not done it any harm. Upton himself recognized the fact that his tactics were not such as they should be, and at the time of his death was revising them. (3) I have discussed before. (4) Mr. Fullam has not considered No. 3 of my points, in which I have desired "a general principle for advancing into action, which would apply to all bodies of men, *large or small*, so as to maintain cohesion from the highest officer down to the single private." I think I have met the modern requirements in my plan, although I may not deploy my men quite as Mr. Fullam would desire. I achieve the same result of getting my men into the firing line, while I keep them under a system of command all the time. I have a "direct movement," while I can manœuvre my men if necessary, and my men are more "free to push forward, as required, according to the ground." Distances can always be changed at will, and have to be left to the commanding officer. I do not violate my own points, but Mr. Fullam has in many cases read between the lines without seeing what was above or below. My plan of three still exists; I give one third to each line because I think the distribution to the different lines will have to be changed as the machine and repeating arms come into more general use.

In regard to the defenses against cavalry, Mr. Fullam puts words into my mouth that I did not know were there. I do not intend to rally my companies so as to form an echelon of companies, for I have said "that the day of rallying by companies is, I think, over." I had my brigade standing in column of companies, threatened by an attack, and this is the formation I would prefer, as it is easy to make. If my men were deployed in sections or groups I would receive my attack in them. Artillery does not generally accompany infantry, but is employed on commanding eminences; cavalry will seldom charge up hill; infantry acting as a support for artillery will therefore be comparatively safe from calvary. If a strong skirmish line can be thrown out, the cavalry will hesitate a moment before charging in between two fires; if they attempt to sweep out the skirmish line, the main body will most likely decimate them. I am sorry that Mr. Fullam regards my formation and subsequent movements "long and rather intricate," when they consist of, in one case, a "forward march" of three companies and a "right half wheel" for six; for the other case, an "about face" and "left half wheel" for three, followed by an advance and the same "right half wheel" for six. Since this is a long and intricate manœuvre, it may account for Mr. Fullam not getting a good idea of my paper, in which some of the points are rather more intricate.

Ensign F. J. HAESELER, U. S. N.*—There is no doubt but that our tactics need modification and adjustment to suit the magazine rifle and the more rapid movements required in the manœuvres of the present day, but at the same

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time, if such modification or change is to be made, it should be of such a character, if possible, as either to cause little or no confusion in the existing formations, or such that the complete organization and system be entirely renewed.

It is evident that if the former can be done it will be much the better, and to that end any change that will tend to cause confusion, by having the proposed manœuvre similar to the one in use and yet different in the minor details, such as orders, etc., should be discouraged. If the present system of Upton's were not in use and I were asked my opinion of Lieutenant Mahan's paper, I should say that it was a most excellent idea; but as it is, I wish to call attention, briefly, to the similarity—in fact, sameness of the method proposed and the one now in use, and further, that where there is any minor difference it is in favor of Upton's.

Before doing so, let me show that the present organization adapts itself to the particular points quoted by Lieutenant Mahan:

"1st. A simplification of the formations, giving the utmost freedom of movement, and developing an individual order."

Our formation is based on a unit of four. This unit can be handled by itself, with one, two, or any number of similar units, and can be subdivided into half units, and further, into individuals. It further admits of changing the unit of four into one which, while acting as a unit of four, contains eight men, very aptly called groups by Lieutenant Mahan, which is similarly capable of being massed with other groups or units, or of being subdivided into individuals. This is likewise done in the system suggested, with the exceptions that three is used as the unit, and further, that the unit cannot be subdivided into half units, which is sometimes convenient.

"6th. In addition, a thorough command, a development of comradeship in small groups, giving rallying power to small parties."

This is likewise attained by the Upton system, as the march in groups (fours) and the deployment and rallying by fours give the results desired.

Lieutenant Mahan begins with the individuals and drills them at setting up drills, the facings, etc.; he then drills them as units, then as groups, then sections, companies, and finally battalion or brigade. In the present day we do the same thing, with the exception of having four as our unit instead of three.

In the proposed organization the men have no numbers to remember; they are simply men, standing as regards certain centre men, and, as the author seems to make a point of this, let me call attention to the fact that they *must remember* what position is occupied by them. No. 1 must not remember that he is No. 1, but he must remember that he is on the right of the centre man,—or, if the men are so drilled that they will always have the same positions, and will rally always by instinct in a certain direction, and should happen to be faced to the rear, what would result? No, I doubt very much the efficiency of not having the men required to have numbers. In the present system the front rank men, with the exception of one in every four who stands fast, deploy and rally *in the same direction*, while in the proposed scheme one third stand fast, one third rally in one direction, and the remainder in the other. Again, when in company, in case of assembling during battle, if one of the men on the right

of the company were missing, all the rest would be out of their regular places, and then our original No. 1 has to remember that now he is on the left of the centre man and rallies to the right, instead of being on the right of the centre man and rallying to the left. Would it not be much better to stick to the present system even if three should be adopted as the tactical unit and count off? How much easier for instructors and recruits it would be to say that No. 1 obliques to the right and front, No. 2 proceeds directly to the front, and No. 3 obliques to the left and front in the deploy, than to go into such general terms as the centre man, the man on the right of the centre man, and the man on the left of the centre man. No better illustration of how simple the number system is can be had than that Lieutenant Mahan uses the numbers 1, 2, and 3 in his explanations, saying that No. 2 is always the centre man, etc.

The units and groups being the same as those in present use, we pass to the sections, which comprise three groups each, and that is simply the same as though our platoons were limited to a certain number of fours, which they could be if deemed advisable. Here let me call attention to a violation of the first point quoted by Lieutenant Mahan. If a section marches in column of groups, the distance between the breast of one man and the back of the man in front of him will be only 21 inches (in column of fours it is 32 inches), and, as the length of the direct step is 30 inches, it will necessitate what is commonly known as lock step marching, which is very tiresome to the men.

The modification, then, in the organization comes in the company, which is divided into three platoons or sections; the first lieutenant being in charge of the right section, the second lieutenant in charge of the left section, and *no one in particular* in charge of the centre section. This organization gives a company front of 108 men on the skirmish line in time of war, which, with intervals of five yards, would make it extend over 540 yards, about one third of a mile, which would be rather a white elephant on the hands of a captain with two officers, even provided neither of them were shot down early in the engagement. They may have to be assembled and transferred suddenly somewhere else; the survivors come together, the middle men are no longer middle men, and the first lieutenant happens to be shot down and some one else must count them off, both of which incidents (they can hardly be called accidents) will cause delays—while the assembly, according to the present tactics, will admit of counting fours and marching off at once whether the first lieutenant or any lieutenant or file-closer is there, and in addition, a company can count fours in less time than an officer can divide off into groups of three files each.

The manœuvres of the units in the different marchings by the flanks and to the rear are the same as at present used, as is also the deployment of the group, with the exception that it is made on No. 2 instead of No. 4. This is an error, since it will take one quarter longer time than necessary to deploy a group of men, or, in other words, deploying a group on No. 2 front rank will take the same time as deploying a complete four (eight men) on No. 4 front rank, inasmuch as No. 3 of the rear rank of the group will have 20 yards to go to the left; hence the inadvisability of using No. 2 as the centre man is apparent.

This being the only difference in the deployment of the group from that of Upton, it would hardly do to make such a change in our tactics.

The sections are drilled in the same manner as the platoons or companies are at the present day, and all the manœuvres and deployments, made according to the proposed drill, can be and are executed according to Upton's tactics. In the battalion the only difference discernible is that after the battalion has deployed into companies, with intervals, as is done by Upton (Art. 332, page 135), the companies are subdivided into sections before deploying into groups. In my opinion this is an error, as it necessitates half of each section except the centre section going twice over the same ground.

The deployment from column of groups forward into skirmish line is an excellent one, and could be done according to Upton's tactics if it were authorized by the Adjutant-General, as it is a perfectly similar manœuvre to "In single rank, left front into line," and could be so executed, substituting the words "In skirmish line (so many yards interval)" for "In single rank." The deployments to the rear can be executed by wheeling the battalion about by fours, which will take but little more time than the about face, as the file-closers, lieutenants, and others, would have to be ordered to the rear before the deployment was made. In addition to the fact that all the manœuvres prescribed in the above paper can be and have been done according to Upton, the deployment forward, or to the rear, by the numbers is *not possible*, as the men *have no numbers*. This formation of the skirmish line I consider as being, if not the most important, one of the most important, as then the number of officers per yard front of fighting line is very much increased, and no company is disproportionally weakened by any particularly heavy loss on the skirmish line. In addition to that, as one, two, three, or more lines can be formed without any intricate manœuvring, and the necessity of having skirmishers thrown out in such a formation that they can be quickly relieved or assisted seems to be a well recognized matter, it would seem to be of too much value to be neglected.

There is another point in which I must differ from Lieutenant Mahan, and that is in his method of rallying. Rallying, when deemed advisable, has a two-fold object, to cause demoralization in the enemy's ranks, and to have a formation that will protect, by the bayonet, from the sabre of the cavalry. It has the disadvantages that the target presented by the group to the revolver of the cavalry-man is much larger, and the chances of some one of the group being hit very much greater than when deployed, and also that valuable time is lost in the rallying and deploying, during which the body is more exposed. Lieutenant Mahan suggests that the rally shall be used, and that as soon as *one volley* is fired the group or unit deploys. Of what use is a magazine gun if it is not to be used on such an occasion, and what demoralization would a volley of three or six rifle shots, even if fired together, carry into a body of cavalrymen when on a charge? If men must rally, let them fire as rapidly as possible in volleys, and as long as possible, and if they can thus turn a charge it will be time enough to think of deploying. I do not pose for a tactician, but I do think that the open order formation, the men being armed with magazine rifles, will stop any ordinary cavalry charge.

It has occurred to me that, judging from the manner in which the different evolutions are performed, Mr. Mahan has intended to follow Upton as closely

as possible, and with that view has made the evolutions the same. We then would have the question reduced to whether there are any such glaring defects in the system that has four as a unit as to make it necessary to adopt some other number, and further, whether the adoption of three as a unit would obviate those defects. This change would cause a vast amount of confusion in the service, and furthermore, would differ from the Army, and as far as I can see would be of no benefit or tend in any way to increase our efficiency as a military organization.

The artillery at present conforms to the infantry, the battalion being divided into any number, usually four, of batteries, the batteries into two platoons, and the platoons into two sections.

If it were desired to carry the comparison of the unit to the fleet, we have four divisions, the van, centre, rear, and reserve divisions; but why skirmish drill should be connected in any way with the manœuvring of ships I fail to see.

Lieutenant D. H. MAHAN.—In all tactics there is a general sameness, but I am not so sure that the odds are all in favor of Upton and against mine, as Mr. Haeseler says. I have not held that Upton's did not possess some of the requirements of my first point; but let me call Mr. Haeseler's attention to one point of which Mr. Fullam complained in his discussion, "the wheel about by fours." On one occasion I saw a battalion so mixed up, by a wheel about and two or three subsequent orders, that it was considered best to break ranks and reform the companies. (During this part of the manœuvre point No. 1 was fully carried out.) This may be simple, but I fail to realize it. By my system the men face about and manœuvre in exactly the same way as before; besides, it makes no difference to me where my men may stand as long as there are three left to drill, consequently there is no chance for such confusion as I have quoted.

Again, in developing my section (or company) I can deploy all my front rank —or a part of it—and my system still continues. Upton deploys Nos. 1 of the front rank and his system of fours (claimed by Mr. Haeseler as existing throughout) is broken up. My deployment can be assembled in small groups, no matter how they deploy. Let Upton deploy Nos. 1 and 3 and desire to rally them in small groups, can you do so? No; you have to rally either on the right or left skirmishers, for there is no designated centre skirmisher, and in making this rally the men have to traverse a good distance of country, from one end of the line to the other, and then present a large target to the enemy, with several of the men well tired out after a spin of from 80 to 115 yards. There is the utmost freedom of movement in this also.

Mr. Haeseler quotes my 6th point in favor of Upton; but after fours have been deployed, who looks out for the set of fours in case the lieutenant and non-commissioned officers have been disabled? What comradeship is developed when you deliberately break it up by deploying by the numbers? There is none, and, being deployed by numbers, there is no rallying power to small parties. In my system there is command throughout, no matter how you deplete the company, group or section. Until there are but two left, the system and command is complete throughout. There is always rallying power

in small groups, since my system of threes is never broken up, although Upton's system of four, which Mr. Haeseler says prevails throughout, does not in this instance.

There is no necessity for dividing my unit into halves, as I cannot see where two men could be of more use than three, and the odd man might decide. I do not believe in having numbers if it can possibly be avoided, and had I been writing a tactics no numbers would have been used. It is usual to make explanations as simple as possible in an address delivered before a society; the members of the Institute having been accustomed to using numbers, it made the subject more easily understood than if I used right, left, and centre, as I have done in the remainder.

It is very easy to compare my divisions of companies with Upton's, but the words "as though" say a great deal, nearly as much as "if." Again, in reference to the lock step so dreaded by Mr. Haeseler, he forgets that "route step" is the general gait on the march; distances are not kept intact. On the battle field no step taken by one man will interfere with any one in front of him. The cadets here march in column of twos with a very quick step and do not seem to feel it tiresome.

Quoting Mr. Haeseler's words italicized, "no one in particular." Again Mr. Haeseler has not read my paper carefully, or wilfully ignores it. If he had read carefully and remembered other parts besides what his attention was on for the moment, he would have noticed in the section deployment these words: "the lieutenant in charge of *section*, while commanding all, looks out *principally* for the *centre group*." He must have known that by my system it is necessary only to interpolate words (always increasing one step) to suit all cases, as: "the *captain* in charge of *company*, while commanding all, looks out *principally* for the *centre section*." He must have seen, but failed to grasp, many points in my address, as further on I say, "the captain and lieutenants . . . . over the sections."

Knowing that a company extended would be rather a white elephant, by my system I have resolved Mr. Haeseler's white elephant into three intelligent but smaller animals, easily guided by a lieutenant, which is something Mr. Haeseler does not do; he prefers to bind in his elephant's trunk and tail and to hunch up his back, or in other words, he prefers to keep his men closer together and in more ranks, presenting a better target to the enemy simply so that the captain can have entire control. Is this developing a thorough command throughout even to small parties? And then the idea of assembling and counting off by fours on the battlefield!

I have shown in my discussion of Lieutenant Fullam's paper that I have gained 13 paces per man in the advance of the front unit of three, as against the front rank of fours. Let us now consider what Mr. Haeseler says on the subject of both ranks. The movements of each man by paces are about as follows:

Upton.		*By threes.*	
No. 1 front rank,	20 paces.	Right front rank,	7 paces.
No. 2 " "	15 "	Centre " "	5 "
No. 3 " "	10 "	Left " "	7 "

Upton.	*By threes.*
No. 4 front rank, 5 paces.	Right rear rank, 22 paces.
No. 1 rear rank, 10 "	Centre " " 20 "
No. 2 " " 15 "	Left " " 22 "
No. 3 " " 20 "	
No. 4 " " 25 "	

or three paces in favor of my system. So that I can move my men each three more paces forward by the time Mr. Haeseler has finished his deployment, consequently, all things being equal, my men will be three paces nearer the enemy than Mr. Haeseler's men. He does not mention the fact that Upton, in his deployment in groups, marches over a certain amount of ground, then, when they deploy, three men in every set of fours (except the one moving forward) have to retrace their steps; that is almost one half of the whole instead of half of two-thirds as in mine. Also my deployment can be without this; and if I deploy at once by groups, my gain as to paces increases over Mr. Haeseler's. To go a step further in the mathematical line for the benefit of both Mr. Haeseler and Lieutenant Fullam: after deploying as above, let the two rally, mine on the centre front rank leader, Mr. Haeseler's on No. 4 front rank. The distances for my men will be $5+5+10+15+20$ paces, equal to 55 paces; for Mr. Haeseler's men, $5+10+15$ and $5+10+15+20$ paces, equal to 80 paces. Now deploy; Mr. Haeseler's men have moved 160 paces and my men only 110 paces, a clear gain of 50 paces of work.

It is not my intention to have my file closers pass through the ranks; it is unnecessary with carefully drilled troops, as the march is never long to the rear. If necessary they can be ordered to the rear, passing through at sergeants' positions.

As to the formation of the skirmish line by numbers, I do not like it, as I have said before, on account of there being no essence of command nor comradeship. Mr. Haeseler seems to think that a large number of officers is necessary on the skirmish line. Never more than one officer to 18 or 36 men is necessary, and that is my allowance. Mr. Haeseler also forgets that I can throw out three lines from one company if necessary, and these will each cover a space varying from 90 to 180 paces, with any desired distance between lines, and in each of my lines my system is complete, while the system of fours ceases to exist. I am sorry to see Mr. Haeseler put himself in opposition to such an authority as Sir Lumley Graham, who says, "The firing line [skirmish line according to Mr. Haeseler] has to fight out the battle through all its stages to the very conclusion." And again, as one of the general principles universally accepted by three of the great continental powers, I will quote (7): "A tactical body once thrown into a firing line on the offensive, *cannot* be relieved; its remnants, great or small, *will remain* in the firing line to the end of the action." There is nothing said about relieving here, but just the opposite, and the work from which these words are quoted is an analysis of the tactics employed by the German, French, and Austrian armies. This is his conclusion, after a careful study of the tactics of three great nations, expressed for the benefit of a fourth great nation; whence, then, does this "well recognized" matter come?

How Mr. Haeseler can say that my rally, when I do allow it, will present a larger target than the rally by fours, I cannot understand. By my rally three or six men come together; in his rally, eight men, or, to say the least, four. In fact, all my thoughts have been against the rally. I say the rally *might* be made, not *shall*, as Mr. Haeseler makes me say; and I even quote, "good infantry need not fear the attack of cavalry, even if in open order," so Mr. Haeseler again misquotes me by speaking of the rallies to which he refers as though I intended them against cavalry. I say, "if it is desired to concentrate fire on any one *spot*," and I also say to deploy on delivering their volley, "unless under cover." It would be suicidal to keep men together under the fire of such a gun as the Maxim, but it might be necessary, for a moment, to concentrate the fire on some one of the enemy's guns. I also quote, "Good infantry need not fear the attack of cavalry, even if in extended order. As a general rule they should be able to maintain the formation in which they happen to be when threatened. To do otherwise would only be to play the enemy's game." And again, "There is one evolution that should *not* be attempted . . . . . rallying by companies to resist cavalry." So how Mr. Haeseler worked in his cavalry I do not know. Mr. Haeseler judges wrongly when he thinks my intention has been to follow Upton as closely as possible. My deployments are different from Upton's, while I can deploy as Upton does, except as to numbers, and as I have shown, more quickly. I have my company differently divided from Upton, but I can drill it the same as Upton drills a company. His plea that this change would cause confusion is not a good one, as that confusion is bound to come if we would *not* differ from the army, as a change in our tactics is coming.

That Mr. Haeseler may fail to see how skirmish drill is in any way connected with ships I can readily understand, as nothing is said in reference thereto, but this is only one more instance of misquoting.

Lieutenant L. W. V. KENNON, Sixth Infantry, U. S. A.—In submitting the following remarks by way of discussion of Lieutenant Mahan's system, I shall confine myself simply to its application to the infantry arm of the service.

In developing his ingenious system of drill he has evidently been governed to a great extent by the principles enunciated in Colonel Macdonald's lecture. In these principles he has found a statement of the conditions to be fulfilled in any effective system of infantry drill adapted to "modern requirements." He has attempted to develop a system which shall fulfill these conditions, and that he has succeeded in doing so cannot be questioned. The importance of closely scrutinizing these conditions, the foundation upon which his system is built, is therefore manifest.

Colonel Macdonald objects to the "present style of drill" because it is not applicable to the fighting of battles under existing conditions, and proposes an "interval order," in which men can be drilled "to as great steadiness and accuracy of movement as they ever have been brought in close files. Troops," he continues, "should be trained to move as accurately, as strictly, and as firmly in discipline in open order as they now do in close files. The hard

and fast line which now separates the parade drill from the practical exercise should be removed, and rapid and frequent change from one to the other should be a distinct feature of the training."

The use of the words "open," "extended," "interval," or "dispersed," as applied to an order of battle, is believed to be entirely misleading, and to express a complete misconception of the character of the fighting line of infantry troops on the field of battle. The idea that such troops when engaged in battle must form a line of skirmishers in the "interval order," is one which at this day is confined to those nations only which have had no recent war experience. It is an idea which has taken deep root in this country, where a faulty and inadequate system of drill has fostered and conserved it. General Upton fully appreciated this fact, and realized that the weakness of his system lay in its battle formations.

His tactics evidently presumes an attack in a double rank "line of battle"; skirmishers were to be employed "to clear the way for the main body," "to annoy the enemy and exhaust his fire before the main attack, or to pursue him promptly after a repulse." It is prescribed that "every company of skirmishers has a *small reserve*, whose duty is to fill vacant places and to furnish the line with cartridges." These objects would perhaps be attained by a skirmish line with the intervals of five yards which Upton places between the individuals composing it, but it was not intended, nor could it reasonably be expected, that such a line could of itself win a battle.

The Prussian tactics devised in 1847 was based on the same ideas of the uses of skirmish lines, but their system was such that it lent itself more readily to the requirements of actual service than ours, and it contained the germs of a practical system which has been developed by the experience of 1866 and 1870–1.

It was found impossible to bring troops in column or in line to a direct attack; the skirmish line alone could fire, and soon it became evident that this fire was of the utmost importance in determining the result. The fire of a line of troops in interval order was found to be insufficient to accomplish decisive results, and in order to obtain the maximum amount of fire action the skirmish line was increased in strength until it contained as many men as could be placed in it and still allow every man sufficient space in which to use his weapon. This was the only limit to the number of men placed in the skirmish line. It is not therefore an "extended," "dispersed," "interval" or "open" order line at all, but an *individual order* in which every man within certain limits had complete freedom of action.

The German authorities think that one man to every running yard of front occupied by the firing line will produce the maximum amount of fire action. The French prescribe that "when it becomes necessary to begin firing, vigorous action is required with a number of rifles sufficient to obtain an appreciable result in little time. . . A rifle must be placed wherever it can be usefully employed. . . Consequently, when on the offensive at the moment of opening fire, the men are placed with intervals of about six inches (15 centimeters) from each other." This interval, it is well to note, is exactly the same

as that between men in all formations for drill and manœuvre. In other words, the French make no provision whatever for a line of skirmishers in "open" or "extended" order.

These principles being those adopted by the nations best qualified by experience to judge in such a matter, demand consideration and respect. They are opposed absolutely to our commonly accepted ideas of "extended order fighting lines." In the systems to which reference has been made there is in fact no extension. A fighting line covers only the front occupied by the tactical unit to which it belongs, this unit being supposed to be in line and in close order. The part of the unit in rear of the fighting line reinforces the latter according to its needs, and eventually becomes absorbed in it. The reserve is not a "small one," as Upton prescribes, but is many times as strong as the fighting line. Instead of dispersion we find, on the contrary, that the use of rapid-loading arms has resulted in concentration; more men are required to occupy a position of a given extent of front than has heretofore, in modern times, been considered necessary. On the offensive the number is placed at from six to seven men; on the defensive, at from four to five per running yard of front. This practice of the most advanced European powers is unquestionably based on the soundest of theoretical considerations.

The conduct of troops on the firing line next demands some attention. Von Boguslawski has probably given us the most technically accurate description of infantry engaged in modern battles to be found in military literature. He states that the enemy was approached "by a succession of rushes. This was done either by taking advantage of cover, or else the men would advance about a hundred yards at a run, throw themselves down, and then run on again. . . This advance would occasion separate strokes and counter-strokes, which naturally caused the tide of battle to roll backward and forward. At this period the fight would attain its highest pitch of intensity. The fire of the breech-loader on both sides resounded unceasingly. . . If fresh detachments came up from the rear during a stationary musketry fight, whether to strengthen the line of fire or to make an attack, it was necessary to double these up with the old skirmishers, because closing the latter to a flank was not usually to be thought of; thus men of many different battalions and regiments were intermingled. . . If the ground was broken, the intermingling and dispersing of tactical units was uncommonly great. . . During the forward movement they (troops) dissolved themselves and ran on to join the skirmishers so as to get at the enemy as soon as possible. . . The men would rush on impetuously and would soon be driven back a bit by a counter-attack of the French." Von Boguslawski speaks of "the disorderly forward rush" of the skirmishers, and of the fight as being a "bloody melée"; of skirmishing as being "pell mell work." This competent witness shows us the reality of an infantry fight, and that confusion must inevitably result from the mode of action forced upon troops in battle, as indeed the rapid forward advance, the rushes for covered positions, the independent firing, the advance of supports, and the losses would lead us naturally to expect.

The kind of "open order" drill that Colonel Macdonald advocates would

find as little practical application on the battlefield as the close order formations he opposes so strenuously. There can be no such precision of movement in battle as he wishes to obtain. The German author I have quoted is very far from recommending any such course of preparation. He says, "Let us therefore practice skirmishing in masses composed of a perfect medley of men. . . Infantry must be accustomed to manœuvre with greater cohesion and rapidity than before. . . The strict Prussian training in close order drill must be continued." The "hard and fast line" which Colonel Macdonald says "separates the parade drill from the practical exercise" cannot be removed. On the contrary, the tendency is toward a wider separation between manœuvring and fighting drill. Tactics may be defined as the method by which troops are formed and moved to accomplish certain objects. The most obvious of these objects are the marching and the fighting of troops. Troops must march and they must fight, and tactics must provide the best means for them to accomplish these distinct ends. The marching formations must be in close order, the closer the better, provided the men can march with ease. The "rigid formations," as they are termed, must be retained for this purpose and for that of massing troops preparatory to engaging the enemy. Drill in these formations is not only advisable but necessary. The army which has proved itself best qualified for the field of battle is the one whose system of "close order" drill is the most complicated. It is not that these "balançoires de champ de manœuvre" have in themselves any application on the battlefield, but there is no doubt that they have contributed in no small degree to the facility of manœuvre which has characterized the German, and especially the Prussian armies in campaign since the time of Frederic, and to which they have owed, particularly in 1866 and in 1870–1, many of their most brilliant successes. Besides being in itself essential, there is no other method known by which troops can obtain the firmness and discipline necessary in individual order fighting so readily or so quickly as in "close order" manœuvres. Both orders find application in war, and neither should be abandoned, but both be practiced. The drill in the individual order would not, however, have any of the "strictness and accuracy" of the interval order advocated by Colonel Macdonald. It is doubtful whether an open order would ever find application in battle. Perhaps it might be adopted by a weak containing force holding a portion of the front of battle, but even in this case its use would be dangerous. It might also be used, as the skirmish line was formerly used, to develop the position and strength of the enemy. The extended order should therefore be retained in view of these possible uses, but it should not by any means be considered as a fighting order, and the limitations of its usefulness should be distinctly understood. For fighting, a stronger, more effective mode of operations is demanded. It is not believed that a system of attack by which a company of 100 men is extended in a line covering a front of over 560 or 360 paces, corresponding to intervals of five or three paces between men, offers many chances of success, for the order of dispersion is for all purposes an order of weakness.

I have dwelt on this topic at some length because of its manifest importance, because of the very general misapprehension of the modern skirmish line and

its functions, and chiefly because evidences of this misapprehension appear in Colonel Macdonald's statement of principles which have guided Lieutenant Mahan in developing his system.

I do not believe the conditions he has assumed are those which exist upon the battlefields of the present time. While his system fulfills all his assumed conditions, it does not present a tactics adapted to the practical work of fighting battles. This must be the crucial test of any such system, and it is in this respect only that Upton's is really inadequate.

The methods of deployment by fours and by threes in the two systems are identical in principle. Both are too complex, and both are believed to be impracticable. The manœuvring of the skirmish line is practically the same in both systems. Rallies are made in similar manner in both. The rallies by "fours," by "threes," or by "groups" for "unit or group volleys," are not practicable on the firing line, nor would they under any circumstances be useful.

The attempt to retain distinction between front and rear rank men on the firing line after the engagement has begun appears in both Upton and Mahan. Any such attempt, or any attempt to advance one rank while the other in rear continues firing, must be futile. The same objection holds in the case where the battalion is deployed in three lines, in which the second line opens a "heavy fire, under cover of which the first line rushes as far forward as possible." Such manœuvres are believed to be unsound in principle, impossible of execution in practice, and fatal only to the advanced rank making the forward rush.

The rallying power of a unit of three or a group of six would not seem likely to have any appreciable influence on the general results should a panic take place in a command of any considerable size.

All the advantages urged for the unit of three or of four on the firing line must disappear if this line be of the strength which it is claimed it must have, or indeed as soon as inevitable losses begin to be felt, or the line reinforced from the rear. All the valid objections urged against Upton's system may with equal force be urged against Lieutenant Mahan's. These are, principally, weakness arising from too great dispersion, the lack of adequate provision for feeding the firing line, and the use of numbers under fire.

Lieutenant Mahan has barely touched on the question of manœuvring formations, though these must continue always to be of great importance. It is not believed that the unit of three lends itself to these formations in so complete or satisfactory a manner as that of four, which has under some form or other been adopted in the manœuvre tactics of all civilized nations.

We come now to the special features of Lieutenant Mahan's system which arise from his application of the factor of three. The plan of organization has the merit of simplicity. It does not in all cases find the approval of authorities on this subject; for instance, the battalion of four companies is universally recognized as the simplest and most effective yet devised. The company of four sections is believed to be better adapted to manœuvring than one of three. The number of intermediate links in the chain of authority between the captain and his men may be considered a defect. It would seem

to be a weak point in the system that one third of the men in a company control the remainder; as file-leaders they "direct and give the word to fire" to the others. These file-leaders, it must be noted, are not selected for fitness, but become file-leaders as they happen to fall in when the company is formed—in other words, by chance.

The claim that numbers are not employed in this system cannot be sustained. "Counting off" is not "done away with" at all. It is simply transferred from the privates to the lieutenants, who "count one, two, three; one, two, three; one, two, three. No. 2 is always centre man." Each man must remember his number in his particular set of three; otherwise manœuvring is not possible. No essential manœuvre is provided for in this system which cannot be accomplished by units of four as well as by units of three. There would even seem to be some advantages possessed by the unit of four not possessed by the unit of three.

To sum up, the geometrical progression organization possesses only the advantage of a theoretical simplicity over many others. A tactics based upon this organization would present no features of superiority over others in which the ratio of three did not enter.

The particular system discussed fails equally with Upton's in providing effective formations for fighting, and is inferior to the latter for manœuvring.

Lieutenant D. H. MAHAN.—I do not only form a line of skirmishers in interval order, but my interval order extends throughout all—intervals between companies, between sections, and between groups—the intervals gradually becoming shorter as the divisions become smaller, until the line has at last attained the consistency of a line of battle, when the assault is to be made.

The Prussian tactics, devised in 1847 and developed in 1866 and 1870-71, have been kept alive (if we can believe semi-official rumors) only by the old Kaiser's wish that the tactics should not be changed during his lifetime, but now we hear of a great change in German tactics, which is awaited with much interest.

I have judged it was impossible to bring troops into action in column or in line, hence the subdivision of my line or column becoming smaller and smaller, but with the ultimate object of forming into that "individual order" which Lieutenant Kennon desires. The space I allow, with all my men in the firing line, is about five yards to every three men—a little more space than the Germans allow, and if exposed to the fire of such a gun as the Maxim, scarcely enough.

Considering myself that "the fire of a line of troops in interval order was insufficient to accomplish decisive results," I make an allowance for keeping my men together until such time as I conceive it necessary to form smaller assemblies.

Mr. Kennon says the French make no provision whatever for a line of skirmishers in open or extended order. Let me quote a few words from the "Ecole de Bataillon": "At 800 meters rifle fire becomes dangerous, the groups extend in rear of the scouts, who, being picked marksmen, open fire in reply

to that of the enemy. The fighting line pushes on from shelter to shelter, and as soon as it becomes necessary to do so, in order to ensure superiority, the 'chaine' joins the scouts." What is this "chaine"? "The 'chaine' is formed of 'escouades,' each consisting of from four to seven files at six paces interval. These 'escouades' (groups) do not, however, at once extend . . . . until the enemy's fire is felt, when the group extends." What are these scouts allowed at the rate of two to every group? Upton's Nos. 1 and 3 of the front rank as skirmishers.

Suppose we consider (in reference to the front of 560 or 360 paces) the attack I have mentioned in column of companies. Deploying as mentioned, I have a "medley of masses" composed of a "medley of men." The first company deployed in a group formation until necessary to move into the firing line; the second company in section formation, breaking into groups and then into "individual order," ultimately rushing up to the firing line; the third company marching as a company in reserve, then broken into sections and then into groups, until in their turn rushed forward into the firing line, which now has (barring casualties) 300 men in the 560 or 360 paces. By this mode of attack will be brought about the mingling of different tactical units, for on the right I would have the right sections of three companies and so on along the line. When I deploy my company I have said the rushes will be by sections—if a battalion were deployed the rushes would be by companies, if possible, otherwise by sections—I wish to rush as many men as possible commensurate with safety (although everything must be risked to win); this causes a "succession of rushes." I say that the assemblies or rallies should take place (not at the same time along the line) if necessary. Would this not allow the old skirmishers to double up with the new detachment coming up? My system allows for the dispersing of tactical units, but at the same time strives to have some order come out of such chaos as Von Boguslawski presents to us.

In regard to the number of intermediate links being a defect, "a complete maintenance of the chain of responsibility, from the commander-in-chief down to the leader of the smallest squad in the fighting line," is called for by the armies of Germany, France, and Austria. In deploying in the firing line is the only time that the leader in the rear rank assumes any responsibility. Consequently the front rank leader is the one, and is one sixth instead of one third of the group. To show that they are used in other armies, let us consider the "sammeln" of the Austrian army. It means a "forward assembly," and is thus performed. A body is in close or open order and wishes to cross a patch of open ground exposed to fire. *The leader* points out the place where *he* wishes the men to assemble, and they run across to it singly or in files and reform. (The "schwarmline" consists of groups, each containing from four to seven files.) Is not *the leader* in my squad, and is it not for him to act as above, command he three or six men? I would call Mr. Kennon's attention to my remarks in answer to Mr. Fullam and Mr. Haeseler in regard to deployments. I think in that it is superior to Upton; the distances can of course be diminished if practice should require it. I have not seen any evidence that this system is inferior to the latter for manœuvring.

In closing my remarks, I would like to present my thanks to the gentlemen who have evinced interest enough in my article to criticise it.

There has been, however, a great diversity of opinion expressed, but in summing up all the differences it seems to me that they dwindle down to three faults—orders, distances, and counting off. Of these I would like to say that a new system should have orders suited to it, and as one of my divisions is a section, I could not use the command "platoon." The order "to the right march" causes the men to move by the right flank, but saves the word flank; the wheels remain the same. Distances are never arbitrary, they can always be changed at discretion; much has to be left to the senior in command. Counting off should be done away with, but only by continual practice can men be accustomed to take nearly the same positions. I have selected eighteen men, as there are but nine in the front rank, nine in the rear rank, and these should be continually trained together, and besides it is in accord with my system.

Finally, I would like to quote a few remarks from a careful analysis of the general principles accepted by three of the great continental powers, compiled by Sir Lumley Graham.

(3) "For the front or 'firing line' the only formation, both in attack and defense, is a line of small sections extended in single rank (which is called a line of skirmishers), which, from being at first *very open*, becomes more and more dense as the antagonists come to close quarters, attaining at last almost the consistency of a line in close order." Does not my attack from column of companies fulfill this point?

(5) "The intermixture of tactical units, which, under the present conditions of warfare, occurs more frequently and on a larger scale than formerly, is an inevitable evil. *All* that can be done is to put it off to a late stage of the battle by means of tactical dispositions, and to minimize its bad effects by training and discipline." Does not my system do nearly all that can be done? Do not tactical dispositions necessitate other dispositions of command, and do I not provide for these dispositions by endeavoring to maintain a thorough command?

(6) "The same training and discipline must regulate infantry fire. If this is to be of decisive effect it must not only be hot and well sustained, but it must also be *entirely under control*, and conducted according to fixed principles, so as to be concentrated upon any point desired." Is not the fire of my system "entirely under control," and "so as to be concentrated on any fixed point"?

(8) "The comparatively loose formations necessary in the present day render supervision and control on the part of superiors more difficult. Tactical dispositions will again do something to remedy this evil, but thorough discipline and training will do more, contributing as they will to the complete maintenance of the chain of responsibility, from the commander-in-chief right down to the leader of the smallest squad in the fighting line." Does not my system do this; is there not a chain right down to the leader of the squad of three?

(16) "In order to get the full value out of the present armament, infantry

should be trained to firing by companies and *smaller bodies* at *long range*, but such firing should only be by word of command." This also can be accomplished by my system, the smaller bodies being groups and sections and all under command.

I should also like to make a few comparisons. "A German company, on a war footing (when manœuvring), is divided into three divisions (zuge), six half divisions (halb-zuge), and twelve sections." My company, on a war footing, is divided into three sections, six half sections, eighteen groups. With the German company when skirmishing, groups of from four to seven files are formed. My groups are three files, but there can be six or nine files.

"An Austrian company on a war footing is divided into two half companies." Is not mine practically so divided?

"In France the company is divided into three echelons. One section forms the fighting line, another the support, the third and fourth sections the reserve. The fighting line is formed of groups, each consisting of from four to seven files at six paces interval. These groups do not, however, immediately extend; on the contrary, each group remains in close order. . . . . This formation is preserved until the enemy's fire is felt, when the group extends." Is not this a good deal similar to my formation? My groups are three files and nine files, but wider separated than the French. My movements in groups are similar, except I have no sharpshooters to throw forward. There are many other points in which my plan can be said to resemble the German, French, and Austrian systems.

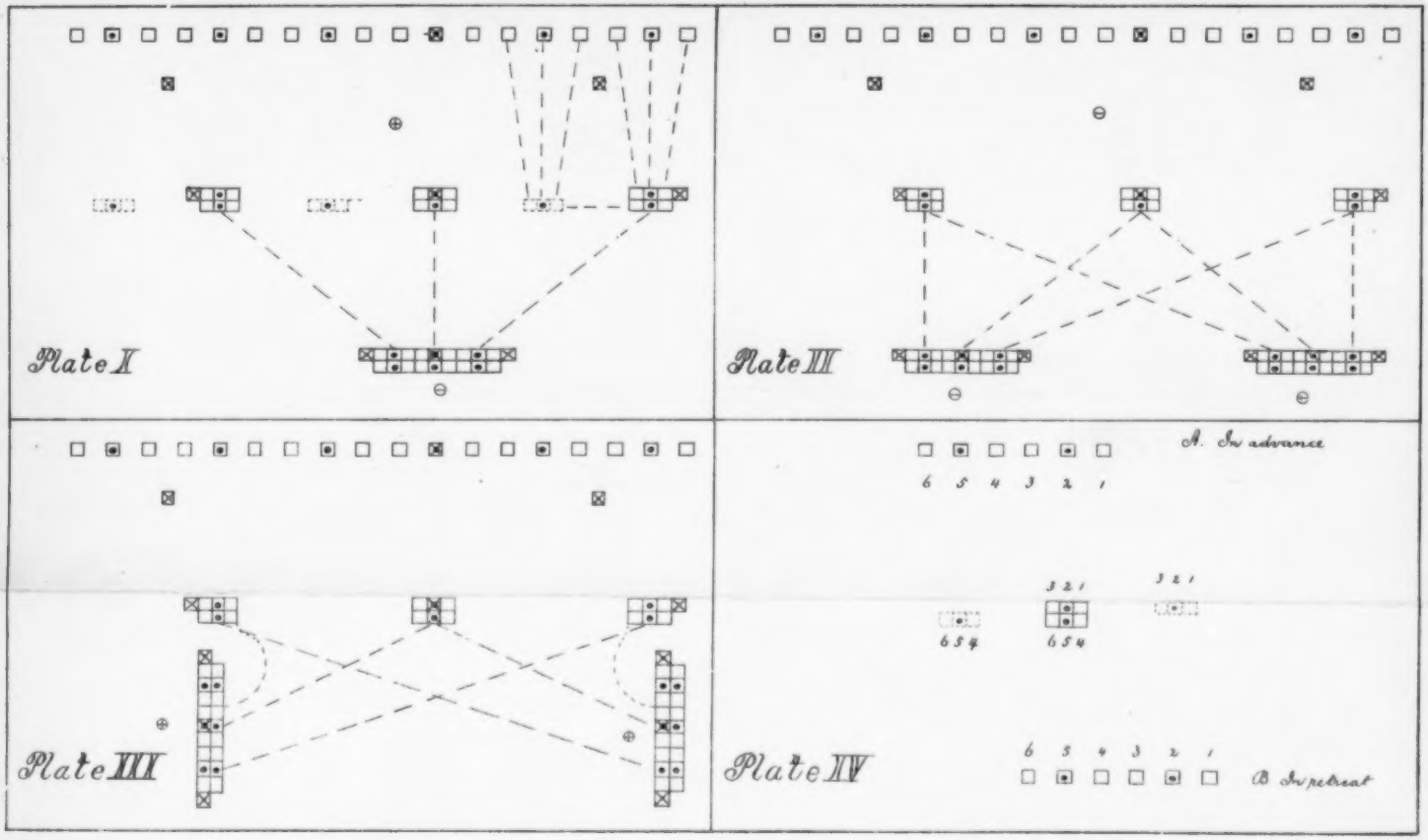
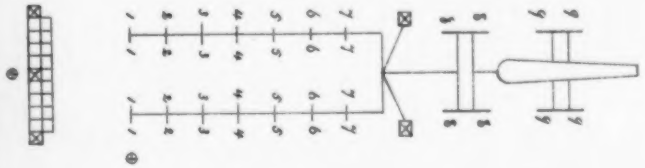


Plate I
Plate II
Plate III
Plate IV
A. In advance
6 5 4 3 2 1
3 2 1
6 5 4
3 2 1
6 5 4
6 5 4 3 2 1
B In retreat

Plate V

Plate XIX



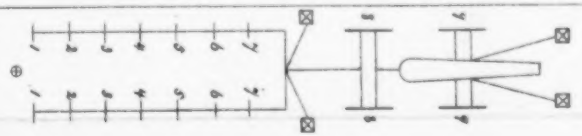
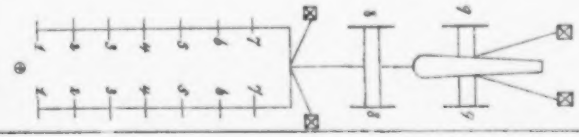


Plate XXX



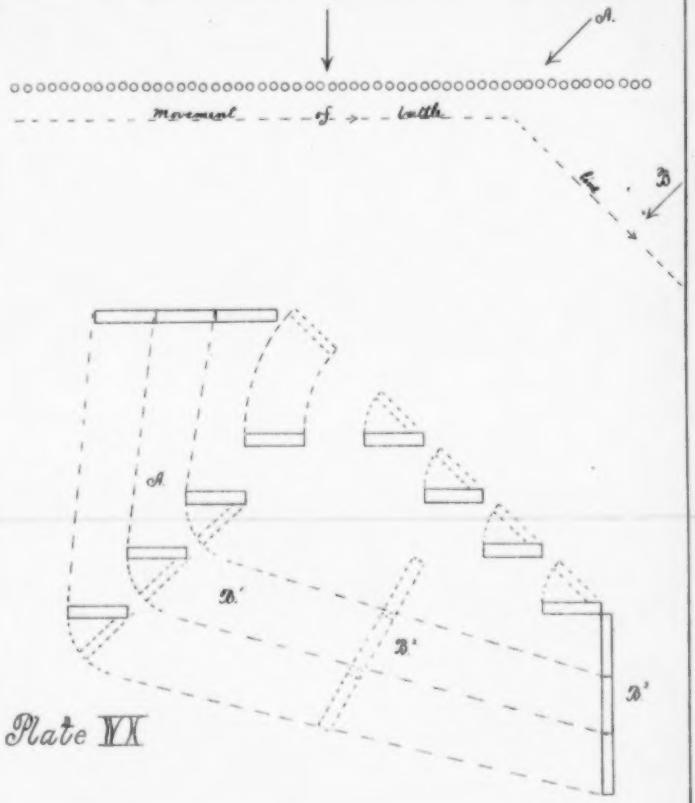


Plate XX

Plate X

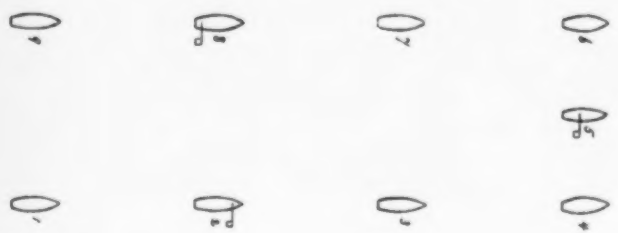


Plate XX

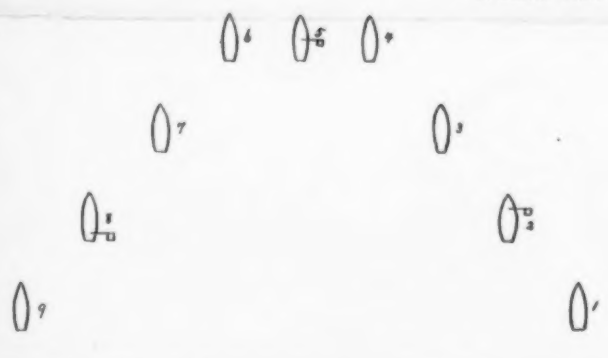
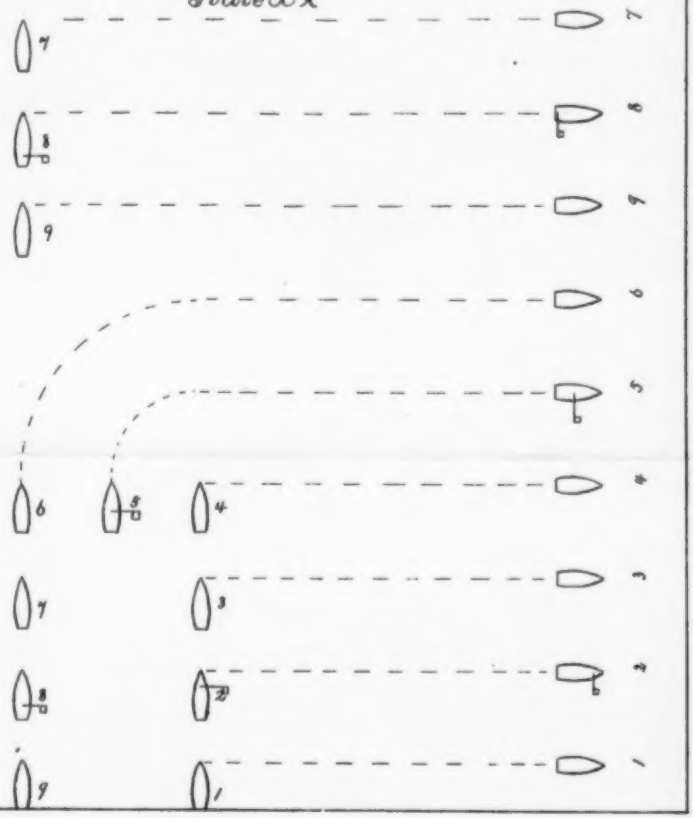


Plate XX



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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

VELOCITIES AND PRESSURES IN GUNS.

By Ensign J. H. Glennon, U. S. N.*

When powder is burnt, either in the open air or in a closed vessel, the products are not all gaseous—a considerable quantity of solid residue is left. The experiments of Messrs. Noble and Abel with varying quantities of powder in a closed vessel furnish data for the calculation of the volume of this solid residue. The pressure, measured with a pressure gauge, is given in each case. As these pressures necessarily follow Mariotte's law, the volume occupied by the powder gases, alone, can be found in each case. This, subtracted from the volume of the vessel, gives the volume of the solid residue. The results obtained by Messrs Noble and Abel, and the calculations of M. Sarrau, point to the fact that the volume of the solid residue, left on exploding powder, is almost exactly equal to the volume of the powder. Assuming this equality, the questions on powder in guns are very much simplified. It is plain in such a case, whether the powder is all burnt at any point or not, that the volume of solid matter, in the bore of a gun when fired, is at all times equal to the original volume of the powder (*exclusive of interstices*).

With the projectile at any point in the bore of a gun, the volume occupied by the gaseous products of powder can be readily calculated by finding the volume of the bore to that point and subtracting from this the volume of the powder.

If δ is the specific gravity or density of the powder, the volume in liters occupied by a weight W of powder, in kilograms, is evidently $\frac{W}{\delta}$. If the volume of the chamber in liters is C, the portion of the chamber unoccupied by solid matter is evidently $C - \frac{W}{\delta}$.

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This is the initial air-space in a gun. By adding to the initial air-space the volume of the bore from the seat of the projectile to the base of the projectile at any point in its travel, we obtain the volume occupied by the gaseous products of combustion for that travel of projectile. Usually the ratio of this latter volume to that of the initial air-space is what is required. This ratio is more readily found by using the *reduced lengths* of these two volumes, which reduced lengths may be defined as being the heights of right cylinders whose volumes are those given, and whose diameters are the caliber of the gun. If c is the caliber of the gun, $\frac{C-\frac{W}{\delta}}{\frac{\pi c^2}{4}}$ is the reduced length of the initial air-space. For simplicity, $\frac{\pi c^2}{4}$ will be denoted by ω. Denoting the reduced length of the initial air-space by L,

$$L=\left(C-\frac{W}{\delta}\right)\frac{1}{\omega},$$

$$\therefore\quad L=\frac{W}{\omega}\left(\frac{C}{W}-\frac{1}{\delta}\right).$$

Density of loading is the ratio of the weight of the charge to the weight of a volume of water that would fill the powder chamber, or is the weight of the charge in kilograms divided by the volume of the chamber in liters. It is evidently the mean density of the products of combustion when they are supposed to fill the powder chamber.

It is denoted by Δ, $\therefore\ \Delta=\frac{W}{C}$. Substituting this in the value of L, we have

$$L=\frac{W}{\omega}\left(\frac{1}{\Delta}-\frac{1}{\delta}\right).$$

If u represents any travel of the shot in a gun, $\frac{u+L}{L}$ is the ratio of the volume occupied by the gases, when the projectile is at u, to the initial air-space.

There are two principal hypotheses on the action of powder in the bore of a gun:

1st. That the gaseous products of combustion receive heat from the solid products as the gas expands, the two being in equilibrium of temperature.

2d. That the gaseous products neither receive nor give off heat, but expand adiabatically.

The 2d is the one followed in this paper. It is true that heat is lost to the walls of the gun, but probably no more than can be accounted for by radiation from the solid residue, the radiating power of which is probably very great, while the emissive and absorptive properties of the gases are probably very small.

If x represents the weight of gaseous products in the bore of a gun at any time;

T_0, the absolute temperature of combustion of powder, or the absolute temperature that the gases would have if no work were done by their expansion;

T, the absolute temperature of the gases in the bore when the projectile is at any point of travel u;

c_1 the specific heat of the gases in constant volume, and

E the mechanical equivalent of heat; evidently we have

$$\text{Heat converted into work} = c_1 x\,(T_0 - T),$$

or

$$\frac{\text{work done}}{E} = c_1 x\,(T_0 - T). \qquad (a)$$

With a unit weight (kilogram) of gas, $P_1 V = RT$, where P_1 is the pressure per unit of area when the gas occupies a volume V at absolute temperature T. The value of R in this equation will give the mechanical equivalent of heat if we divide it by $c' - c_1$, where c' is the specific heat of the gas under constant pressure.* Then

$$E = \frac{R}{c' - c_1} = \frac{R}{c_1\left(\frac{c'}{c_1} - 1\right)}.$$

Substituting this in equation (a), calling $\frac{c'}{c_1}$, n, and dividing through by c_1,

$$(n - 1)(\text{work done}) = Rx\,(T_0 - T) = RxT\left(\frac{T_0}{T} - 1\right). \qquad (b)$$

In the equation above, $P_1 V = RT$, we had a unit weight of gas in volume V. If we have any other weight of gas as x in this same volume, by Mariotte's law the pressure will be multiplied by x, the temperature still remaining T; or if P denote the new pressure,

$$PV = RxT.$$

Equation (b) then becomes,

$$(n - 1)(\text{work done}) = PV\left(\frac{T_0}{T} - 1\right) = PV\frac{T_0}{T} - PV, \qquad (c)$$

* This is one method of determining the mechanical equivalent of heat. See equation 13, page 5, Vol. X., No. 1, Whole No. 28, Proceedings U. S. Naval Institute.

where P is the pressure of the gases in the bore of a gun, and V the volume these gases occupy.

We can still further reduce equation (c) by introducing another function of powder.

The force of powder is the pressure per unit of area (square decimeter) of the gases of a unit weight of powder (kilogram) exploded in a space such that the gaseous products shall occupy a unit volume (liter). It is denoted by f.

If then we explode w kilograms* of powder so that its gases shall occupy a liter, by Mariotte's law the pressure per unit area will be fw. If these gases occupy V liters, instead of one liter, the pressure per unit area will be $\frac{fw}{V}$; and if the temperature of the gases is changed, by work or any other cause, the pressure will be changed proportionally to the absolute temperature. Consequently at temperature T the pressure will be

$$P = \frac{fw}{V} \cdot \frac{T}{T_0} \therefore PV\frac{T_0}{T} = fw.$$

Substituting this in (c),

$$(n-1)(\text{work done}) = fw - PV.$$

If m is the mass of the projectile, and if the energy of the projectile represents the work done,

$$(n-1)\frac{m}{2}\left(\frac{du}{dt}\right)^2 = fw - PV, \text{ or } \frac{n-1}{2}\left(\frac{du}{dt}\right)^2 = \frac{fw}{m} - \frac{PV}{m}. \quad (d)$$

If P is the pressure per unit area on the projectile, $P\omega$ is the entire pressure on its base and $\frac{P\omega}{m}$ is its acceleration. Consequently

$$\frac{P\omega}{m} = \frac{d^2u}{dt^2}.$$

V, the volume occupied by the gases, is $\omega(u + L)$, as stated at the beginning of this paper. Consequently

$$\frac{PV}{m} = (u + L)\frac{d^2u}{dt^2}.$$

Substituting this in equation (d), we obtain the general equation of motion in the bore of a gun,

$$(u + L)\frac{d^2u}{dt^2} + \frac{(n-1)}{2}\left(\frac{du}{dt}\right)^2 = \frac{fw}{m}, \quad (1)$$

where w is the weight of powder burnt at any point, and u the corresponding travel of the projectile.

* w kilograms of powder are supposed to give off x kilograms of gas.

In a gun, unless the powder is very quick, all of it is not burnt. In case the powder is not all burnt, w is not equal to W, the weight of the charge, but is something less. If we know the value of w at any point, the solution of equation (1) for v will give us the velocity at that point. The solution for $\frac{d^2u}{dt^2}$ will give the acceleration, provided that w remains constant for the corresponding element of time dt. If w is variable during this time, $\frac{d(v^2)}{2du}$, treating w and u as variables in the formula for v^2, will be the acceleration.

In fact the expression, $P = Rx\frac{T}{V}$, used in the deduction of the general equation, is only true on the supposition that x is constant, at the point taken, which involves w being constant at the same.

To solve equation (1) it is only necessary to change its form slightly.

Since $\frac{d^2u}{dt^2} = \frac{dv}{dt}$, where v is the velocity of projectile corresponding to travel u, and $v = \frac{du}{dt}$, we have

$$dt = \frac{du}{v}, \text{ and } \frac{d^2u}{dt^2} = \frac{dv}{dt} = \frac{vdv}{du} = \frac{d(v^2)}{2du}.$$

(1) may be written

$$(u+L)\frac{d(v^2)}{2du} + \frac{(n-1)}{2}v^2 = \frac{fw}{m},$$

or
$$(u+L)\frac{d(v^2)}{du} + (n-1)v^2 - \frac{2fw}{m} = 0. \qquad (2)$$

Dividing each member of equation (2) by $\frac{u+L}{du}\left(v^2 - \frac{2fw}{(n-1)m}\right)$

we obtain
$$\frac{d(v^2)}{v^2 - \frac{2fw}{(n-1)m}} + (n-1)\frac{du}{u+L} = 0,$$

and integrating,

$$\log\left(v^2 - \frac{2fw}{(n-1)m}\right) + \log(u+L)^{n-1} + F = 0,$$

where F is the constant of integration.

When $u = 0$, $v = 0$; consequently

$$-F = \log(L)^{n-1} + \log\left(-\frac{2fw}{(n-1)m}\right) = \log\left(-\frac{2fw}{(n-1)m}L^{n-1}\right)$$

$$\therefore \left(v^2 - \frac{2fw}{(n-1)m}\right)(u+L)^{n-1} = -\frac{2fw}{(n-1)m}L^{n-1},$$

or
$$v^2 - \frac{2fw}{(n-1)m} = -\frac{2fw}{(n-1)m}\left(\frac{L}{u+L}\right)^{n-1},$$

and $$v^2 = \frac{2fw}{(n-1)m}\left(1 - \left(\frac{L}{u+L}\right)^{n-1}\right), \qquad (3)$$

which will give the velocity at any point u, provided we know w for the same point.

In case w is burnt instantaneously, and no more powder is burnt in the gun, the formula for velocity can be found by direct integration, assuming that the gases expand adiabatically.

At first, the gaseous products occupy the initial air-space. Their volume then is ωL. Then their pressure per unit area is $P_0 = \frac{fw}{\omega L}$. At any point u, the gases occupy a volume $\omega(u+L)$. If the transformation is adiabatic, PV^n is constant,

$$\therefore \quad P_0(\omega L)^n = P[\omega(u+L)]^n,$$

$$\therefore \quad P = P_0\left(\frac{L}{u+L}\right)^n = \frac{fw}{\omega L}\left(\frac{L}{u+L}\right)^n.$$

But $$P = \frac{m}{\omega}\cdot\frac{dv}{dt} = \frac{m}{\omega}\,\frac{d(v^2)}{2du},$$

$$\therefore \quad d(v^2) = \frac{2fw}{mL}\left(\frac{L}{u+L}\right)^n du,$$

$$\therefore \quad v^2 = \int_0^{v^2} d(v^2) = \frac{2fw}{m}\int_0^u \frac{L^{n-1}du}{(u+L)^n}$$

$$= \frac{2fw}{(n-1)m}\left(1 - \left(\frac{L}{u+L}\right)^{n-1}\right),$$

as before.

Equation (3) can be written, if we substitute for $\frac{u}{L}$, y,

$$v^2 = \frac{2fw}{(n-1)m}\left(1 - \frac{1}{(y+1)^{n-1}}\right). \qquad (4)$$

If the charge is completely burned when the projectile leaves the muzzle, which would happen only with a quick powder, substituting for w the weight of charge W, and for y its value at the muzzle, we obtain a value for muzzle velocity.

It is convenient to have if possible a monomial formula for v^2. This can only be obtained by making $\left(1 - \frac{1}{(y+1)^{n-1}}\right)$ equal to the product of a power of y by a constant. n with perfect gases equals 1.4.

Suppose, then, $\left(1 - \frac{1}{(y+1)^{n-1}}\right) = \left(1 - \frac{1}{(y+1)^{\cdot 4}}\right) = Dy^\gamma$,

where D and γ are unknown constants. Values of y, that will include most muzzle distances with modern guns, are 4 and 9. 4 and

9, then, as values for y, should satisfy the above equation. Substituting them, we have,

$$1 - \frac{1}{(9+1)^{.4}} = D\,(9)^{\gamma},$$

and

$$1 - \frac{1}{(4+1)^{.4}} = D\,(4)^{\gamma}.$$

Dividing the first by the second,

$$\frac{1 - \frac{1}{(10)^{.4}}}{1 - \frac{1}{(5)^{.4}}} = \left(\frac{9}{4}\right)^{\gamma},$$

whence

$$\log \frac{1 - \frac{1}{(10)^{.4}}}{1 - \frac{1}{(5)^{.4}}} = \gamma \log \frac{9}{4}, \text{ or } \gamma = \frac{\log \frac{1 - \frac{1}{(10)^{.4}}}{1 - \frac{1}{(5)^{.4}}}}{\log \frac{9}{4}} = .29.$$

Consequently, substituting for $1 - \frac{1}{(y+1)^{.4}}$, $Dy^{.29}$ or even $Fy^{\frac{1}{3}}$, will give very good results, F being a constant. Making the last substitution, (4) becomes $v^2 = \frac{2fFW}{(n-1)\,m} y^{\frac{1}{3}} = \frac{2fF}{(n-1)} \frac{W}{m} \left(\frac{u}{L}\right)^{\frac{1}{3}}$.

It is customary to eliminate L. To do this we have to remember that a function near its maximum varies very slowly. The quantity $\frac{\Delta}{\delta}\left(1 - \frac{\Delta}{\delta}\right)$ is a maximum when $\frac{\Delta}{\delta} = \frac{1}{2}$. In the conditions of practice $\frac{\Delta}{\delta}$ does not vary much on either side of $\frac{1}{2}$,

$$\therefore \quad \frac{\Delta}{\delta}\left(1 - \frac{\Delta}{\delta}\right) = \frac{1}{4}, \text{ very nearly.}$$

Now L, as before proven, equals

$$\frac{W}{\omega}\left(\frac{1}{\Delta} - \frac{1}{\delta}\right) = \frac{W}{\omega\Delta}\left(1 - \frac{\Delta}{\delta}\right),$$

or

$$L = \frac{W\delta}{\omega\Delta^2} \cdot \frac{\Delta}{\delta}\left(1 - \frac{\Delta}{\delta}\right),$$

$$\therefore \quad L = \frac{W\delta}{4\omega\Delta^2}, \text{ very nearly.}$$

Substituting in the above monomial formula for v^2 this value of L, for ω its value $\frac{\pi c^3}{4}$, for m, $\frac{p}{g}$, where p is the weight of the projectile; and, as the density of powder is nearly constant, calling $\delta^{\frac{1}{3}}$ constant, and placing it, as well as F and the other numerical constants, in a new constant A^2, we have

$$v^2 = A^2 \frac{fW}{p} \left(\frac{c^2 \Delta^2}{W}\right)^{\frac{1}{2}} u^{\frac{1}{2}} = A^2 \frac{fW^{\frac{3}{2}}}{p} c^{\frac{1}{2}} \Delta^{\frac{1}{2}} u^{\frac{1}{2}},$$

$$\therefore \quad v = A \frac{f^{\frac{1}{2}}}{p^{\frac{1}{2}}} W^{\frac{1}{2}} c^{\frac{1}{2}} \Delta^{\frac{1}{2}} u^{\frac{1}{2}}, \tag{5}$$

which is the monomial formula for muzzle velocity, using a powder all of which is burnt in the gun. This formula agrees with experiment. It differs from that of M. Sarrau in one point. He introduces with f another quantity depending on the shape of the powder-grain. As can be seen, however, from the fundamental equation (1) (with which M. Sarrau commences), there can be only one solution for v, for any given value of w, if f is constant.

With slower powders we have to proceed in a different way; w is then less than W, as all the powder is not burnt in the gun. From (4) we have

$$\left(\frac{dy}{dt}\right)^2 = \left(\frac{du}{L\,dt}\right)^2 = \frac{v^2}{L^2} = \frac{2fw}{(n-1)mL^2}\ (1-(y+1)^{1-n}). \tag{6}$$

From (4), by differentiation, we have*

$$\frac{d^2u}{dt^2} = \frac{d(v^2)}{2du} = \frac{d(v^2)}{2L\,dy} = \frac{fw}{mL(y+1)^n}. \tag{7}$$

Dividing (7) by (6), member by member,

$$\frac{d^2u}{(dy)^2} = \frac{(n-1)L}{2[(y+1)^n-(y+1)]} = \frac{(n-1)L}{2(y+1)[(y+1)^{n-1}-1]},$$

$$\therefore \quad d^2u = \frac{(n-1)L(dy)^2}{2(y+1)[(y+1)^{n-1}-1]}. \tag{8}$$

Let l_τ denote the least dimension of the grains of gunpowder of which the charge is composed, the grains being supposed uniform in size, shape and material; let τ denote the time of burning of a grain at the normal atmospheric pressure P_0; and let l denote the length of grain burnt in time t, at pressure P.

The velocity of combustion† of the grain at the atmospheric pressure is evidently $\frac{l_\tau}{\tau}$. If the "velocity of combustion varies as the square root of the pressure" (see Whole No. 28, Proceedings U. S. Naval Institute, page 102), when the pressure is P, velocity of combustion $= \frac{dl}{dt} = \frac{l_\tau}{\tau}\left(\frac{P}{P_0}\right)^{\frac{1}{2}}$.

* This is the acceleration due to $P = Rx\frac{T}{V}$, the pressure of the surrounding medium previous to increase by a change in x; just as in air, P_0 is the pressure previous to a corresponding increase. In either case, if the phenomenon were suddenly stopped, $P = Rx\frac{T}{V}$ and P_0 would be the measured pressures.

† *Velocity of combustion* as here used means twice what is ordinarily understood by that name. With a spherical grain, for example, it is the decrease per second in the length of the diameter.

Substituting for P its value, or $\frac{m}{\omega}\frac{d^2u}{dt^2}$, we have,

$$dl = \frac{l_\tau}{\tau}\left(\frac{m}{\omega P_0}\right)^{\frac{1}{2}}\left(\frac{d^2u}{dt^2}\right)^{\frac{1}{2}}dt = \frac{l_\tau}{\tau}\left(\frac{m}{\omega P_0}\right)^{\frac{1}{2}}(d^2u)^{\frac{1}{2}}.$$

Substituting for d^2u its value from equation (8),

$$dl = \frac{l_\tau}{\tau}\left(\frac{m(n-1)L}{2\omega P_0}\right)^{\frac{1}{2}}\frac{dy}{(y+1)^{\frac{1}{2}}[(y+1)^{n-1}-1]^{\frac{1}{2}}}. \quad (9)$$

Integrating (9), replacing $(n-1)$ by .4 or $\frac{2}{5}$,

$$l = \int_0^l dl = \frac{l_\tau}{\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}}\int_0^y \frac{dy}{(y+1)^{\frac{1}{2}}\sqrt{(y+1)^{\frac{2}{5}}-1}}. \quad (10)$$

The last integral is evidently a function of y alone; denote it by Y_1, and place $\frac{1}{\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}} = K$. Then (10) becomes $l = l_\tau K Y_1$, or

$$\frac{l}{l_\tau} = KY_1. \quad (11)$$

The weight of powder burned, when l is burned, can be expressed with any form of grain by

$$w = \frac{Wal}{l_\tau}\left(1 - \lambda\frac{l}{l_\tau} + \mu\frac{l^2}{l_\tau^2} + \text{etc.}\right),$$

(with most regular forms, by these three terms alone), where a, λ and μ are fixed numerical constants depending on the form of the grain. Substituting in this equation the value of $\frac{l}{l_\tau}$ from (11),

$$w = WaKY_1(1 - \lambda KY_1 + \mu K^2 Y_1^2),$$

and substituting this for w in (4),

$$v^2 = \frac{2fa\,WKY_1}{\frac{2}{3}m}(1 - \lambda KY_1 + \mu K^2 Y_1^2)\left(1 - \frac{1}{(y+1)^{.4}}\right). \quad (12)$$

Calling $Y_1\left(1 - \frac{1}{(y+1)^{.4}}\right)$, Y_0, and extracting the square root of (12), retaining two terms,*

$$v = \left(\frac{5fa\,WK}{m}\right)^{\frac{1}{2}}Y_0^{\frac{1}{2}}\left[1 - \frac{\lambda}{2}KY_1\right]. \quad (13)$$

It is evident that the formula for velocity thus depends for complete solution entirely on the form of Y_1. M. Sarrau assumes Y_1 proportional to $y^{\frac{1}{2}}$. As will be seen later, this power is very approximate. The quantity $\left(1 - \frac{1}{(y+1)^{.4}}\right)$, as stated before, for muzzle distances, varies very nearly as $y^{\frac{1}{2}}$. Consequently Y_0 varies

*The remaining terms are small, and the experimental method afterwards pursued of determining the constants in the second member of (13) almost entirely eliminates the error due to their omission.

very nearly as $y^{\frac{3}{4}}$. Placing $Y_1 = Hy^{\frac{1}{2}} = H\left(\frac{u}{L}\right)^{\frac{1}{2}}$, and

$$Y_0 = H_1^2 y^{\frac{3}{4}} = H_1^2 \left(\frac{u}{L}\right)^{\frac{3}{4}},$$

where H and H_1^2 are constants; replacing K by its value $\frac{1}{\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}}$, and y by $\frac{u}{L}$, equation (13) becomes,

$$v = \left(\frac{5fa\,W}{m\tau}\right)^{\frac{1}{2}} \left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{4}} H_1 \left(\frac{u}{L}\right)^{\frac{3}{4}} \left[1 - \frac{\lambda}{2\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}} H\left(\frac{u}{L}\right)^{\frac{1}{2}}\right],$$

or

$$v = \left(\frac{5fa\,W}{\tau}\right)^{\frac{1}{2}} \left(\frac{1}{5\omega P_0 m}\right)^{\frac{1}{4}} \frac{1}{L^{\frac{1}{4}}} H_1 u^{\frac{3}{4}} \left[1 - \frac{\lambda}{2\tau}\left(\frac{m}{5\omega P_0}\right)^{\frac{1}{2}} H u^{\frac{1}{2}}\right]. \quad (14)^*$$

Substituting for L as before (see deduction of equation (5)), $\frac{W\delta}{4\omega\Delta^2}$, for m, $\frac{p}{g}$, for ω, $\frac{\pi c^2}{4}$, calling $\delta^{\frac{1}{2}}$ a constant, and combining all the constants outside the brackets in (14) in a new constant A, and all inside in a new one B,

$$v = \frac{A f^{\frac{1}{2}} a^{\frac{1}{2}} W^{\frac{1}{4}} \Delta^{\frac{1}{4}} u^{\frac{3}{4}}}{\tau^{\frac{1}{2}} p^{\frac{1}{4}} c^{\frac{1}{4}}} \left[1 - \frac{\lambda}{\tau} B \frac{p^{\frac{1}{2}} u^{\frac{1}{2}}}{c}\right],$$

or as this is usually written,

$$v = A\left(\frac{fa}{\tau}\right)^{\frac{1}{2}} (Wu)^{\frac{1}{4}} \left(\frac{\Delta}{pc}\right)^{\frac{1}{4}} \left[1 - B\frac{\lambda}{\tau}\frac{(pu)^{\frac{1}{2}}}{c}\right]. \quad (15)$$

This agrees exactly with Sarrau's formula and with experiment. The two constants A and B are determined by the actual muzzle velocities obtained (for v) in two dissimilar guns. If weights are given in lbs., and distances in feet, A and B will involve the numerical quantities for the conversion of units. $\left(\frac{fa}{\tau}\right)$ and $\left(\frac{\lambda}{\tau}\right)$ are constant for the same powder, and are generally included in the determined constants.

It is not necessary, however, to substitute for Y_1, $Hy^{\frac{1}{2}}$, inasmuch as Y_1 can be computed without much trouble.

We have $$Y_1 = \int_0^y \frac{dy}{(y+1)^{\frac{1}{2}}\sqrt{(y+1)^{\frac{3}{2}} - 1}}.$$

Place $$z = (y+1).$$

*Note in equation (14) that L occurs to the $\frac{1}{4}$ power. A small inexactness then in the assumption that the volume of the solid residue equals that of the powder will cause little or no error.

Then $$Y_1 = \int_1^x \frac{dx}{x^{\frac{1}{2}}\sqrt{x^{\frac{3}{5}} - 1}}.$$

Let $X = x^{\frac{1}{5}}$, whence $x = X^5$, $dx = 5X^4 dX$, and

$$Y_1 = 5\int_1^X \frac{X^{\frac{3}{2}} dX}{\sqrt{X^3 - 1}}.$$

Let $$X = \sec\varphi \quad \therefore \quad dX = \sec\varphi \tan\varphi d\varphi,$$

and $$Y_1 = 5\int_0^\phi (\sec\varphi)^{\frac{1}{2}} d\varphi.$$

Now,

$$\int (\sec\varphi)^{\frac{3}{2}} d\varphi = (\sec\varphi)^{\frac{1}{2}}\tan\varphi - \int \tan\varphi d(\sec\varphi)^{\frac{1}{2}}, \qquad (16)$$

and

$$\int \tan\varphi d(\sec\varphi)^{\frac{1}{2}} = \int \tan\varphi \frac{d(\sec\varphi)}{2(\sec\varphi)^{\frac{1}{2}}} = \frac{1}{2}\int \frac{\tan^2\varphi \sec\varphi d\varphi}{(\sec\varphi)^{\frac{1}{2}}};$$

or since $$\tan^2\varphi = \sec^2\varphi - 1,$$

$$\int \tan\varphi d(\sec\varphi)^{\frac{1}{2}} = \frac{1}{2}\int (\sec\varphi)^{\frac{3}{2}} d\varphi - \frac{1}{2}\int (\sec\varphi)^{\frac{1}{2}} d\varphi.$$

Substituting this in equation (16),

$$\frac{3}{2}\int (\sec\varphi)^{\frac{3}{2}} d\varphi = (\sec\varphi)^{\frac{1}{2}}\tan\varphi + \frac{1}{2}\int (\sec\varphi)^{\frac{1}{2}} d\varphi,$$

$$\therefore \int_0^\phi (\sec\varphi)^{\frac{3}{2}} d\varphi = \frac{2}{3}(\sec\varphi)^{\frac{1}{2}}\tan\varphi + \frac{1}{3}\int_0^\phi (\sec\varphi)^{\frac{1}{2}} d\varphi,$$

and

$$Y_1 = 5\int_0^\phi (\sec\varphi)^{\frac{3}{2}} d\varphi = \frac{10}{3}(\sec\varphi)^{\frac{1}{2}}\tan\varphi + \frac{5}{3}\int_0^\phi (\sec\varphi)^{\frac{1}{2}} d\varphi, \qquad (17)$$

where $$\varphi = \sec^{-1}X = \sec^{-1}x^{\frac{1}{5}} = \sec^{-1}(y+1)^{\frac{1}{5}}.$$

Now,

$$\int_0^\phi (\sec\varphi)^{\frac{1}{2}} d\varphi = \int_0^\phi \frac{d\varphi}{(\cos\varphi)^{\frac{1}{2}}} = \int_0^\phi \frac{d\varphi}{\left(\cos^2\frac{\varphi}{2} - \sin^2\frac{\varphi}{2}\right)^{\frac{1}{2}}}$$

$$= \int_0^\phi \frac{d\varphi}{\left(1 - 2\sin^2\frac{\varphi}{2}\right)^{\frac{1}{2}}}.$$

Let $x_1 = \sin\frac{\varphi}{2}$; then $\frac{\varphi}{2} = \sin^{-1}x_1$, and $d\varphi = \frac{2dx_1}{\sqrt{1 - x_1^2}}$,

$$\therefore \int_0^\phi (\sec\varphi)^{\frac{1}{2}} d\varphi = \int^{x_1} \frac{2dx_1}{(1 - x_1^2)^{\frac{1}{2}}(1 - 2x_1^2)^{\frac{1}{2}}}$$

$$= \sqrt{2}\int_0^{y_1} \frac{dy_1}{\left(1 - \frac{y_1^2}{2}\right)^{\frac{1}{2}}(1 - y_1^2)^{\frac{1}{2}}},$$

where $$x_1 = \frac{y_1}{\sqrt{2}}.$$

Let $y_1 = \sin\varphi_1$; then $\varphi_1 = \sin^{-1}y_1$, and $d\varphi_1 = \frac{dy_1}{\sqrt{1-y_1^2}}$,

$$\therefore \int_0^{\phi} (\sec\varphi)^{\frac{1}{2}} d\varphi = \sqrt{2}\int_0^{\phi_1} \frac{d\varphi_1}{\left(1-\frac{1}{2}\sin^2\varphi_1\right)^{\frac{1}{2}}}, \qquad (18)$$

where $\varphi_1 = \sin^{-1}y_1 = \sin^{-1}(\sqrt{2}x_1) = \sin^{-1}\left(\sqrt{2}\sin\frac{\varphi}{2}\right)$,

and $$\varphi = \sec^{-1}(y+1)^{\frac{1}{3}}.$$

The last integral is evidently of the general form

$$\int_0^{\phi} \frac{d\varphi}{(1-k^2\sin^2\varphi)^{\frac{1}{2}}},$$

k evidently being $\sqrt{\frac{1}{2}}$, or $\sin 45°$.

It is tabulated under the heading $F(45°)$, Table IX, Tome II, Fonctions Elliptiques, by Legendre (page 331), for every value of φ from 0° to 90°. Evidently then,

$$Y_1 = \frac{10}{3}(\sec\varphi)^{\frac{1}{2}}\tan\varphi + \frac{5\sqrt{2}}{3}\int_0^{\sin^{-1}\left(\sqrt{2}\sin\frac{\phi}{2}\right)} \frac{d\varphi}{\left(1-\frac{1}{2}\sin^2\varphi\right)^{\frac{1}{2}}},$$

where $$\varphi = \sec^{-1}(y+1)^{\frac{1}{3}}.$$

The following is the form of calculation:

Y_1 for $y = 8$.

$(y+1) = 9$,	log .95424		
$(y+1)^{\frac{1}{3}}$	log .19085		
$\varphi = \sec^{-1}(y+1)^{\frac{1}{3}} = 49°\ 52'\ 50''$		$(\sec\varphi)^{\frac{1}{2}}$	log .09542
		$\tan\varphi$	log .07434
$\frac{\varphi}{2} = 24°\ 56'\ 25''$		$\frac{10}{3}$	log .52288
$\frac{\varphi}{2}$	log sin 9.62498	4.9277	log .69264
$\sqrt{2}$	log .15052	1st term of Y_1	
φ_1	log sin 9.77550		

$\varphi_1 = 36°\ 36'\ 30''$

$F(45°)$ for $\varphi_1 = .66081$, log 9.82008

$\frac{5\sqrt{2}}{3}$, log .37237

2d term of $Y_1 = 1.5576$, log .19245

1st term of $Y_1 = 4.9277$

$6.4853 = Y_1$ for $y = 8$.

The values of Y_1 for values of y from 0 to 9 will be found calculated in the following table, as well as the values of Y_0 calculated from $Y_0 = Y_1\left(1 - \frac{1}{(y+1)^{.4}}\right)$. Also the values of

$$\frac{dY_1}{dy} = \frac{1}{(y+1)^{\frac{1}{5}}[(y+1)^{\frac{2}{5}} - 1]^{\frac{1}{2}}}$$

and $$\frac{dY_0}{dy} = \left(1 - \frac{1}{(y+1)^{.4}}\right)\frac{dY_1}{dy} + Y_1\frac{.4}{(y+1)^{1.4}}$$

(obtained by taking the derivative of the above value of Y_0).

TABLE I.

VALUES OF THE TRANSCENDENTALS Y_1† AND Y_0* AND THEIR FIRST DERIVATIVES $\frac{dY_1}{dy}$† AND $\frac{dY_0}{dy}$*.

y	$Y_1 = \int_0^y \frac{dy}{(y+1)^{\frac{1}{5}}\sqrt{(y+1)^{\frac{2}{5}} - 1}}$	$1 - \frac{1}{(y+1)^{\frac{2}{5}}}$	$Y_0 = Y_1\left(1 - \frac{1}{(y+1)^{\frac{2}{5}}}\right)$	$\frac{dY_1}{dy} = \frac{1}{(y+1)^{\frac{1}{5}}\sqrt{(y+1)^{\frac{2}{5}} - 1}}$	$Y_1\frac{2}{5(y+1)^{1.4}}$	$\frac{dY_1}{dy}\left(1 - \frac{1}{(y+1)^{\frac{2}{5}}}\right)$	$\frac{dY_0}{dy} = Y_1\frac{2}{5(y+1)^{1.4}} + \frac{dY_1}{dy}\left(1 - \frac{1}{(y+1)^{\frac{2}{5}}}\right)$
0	0	0	0	∞	0	0	0
.1	.98851	.03742	0.03699	4.8342	.34601	.18090	0.52691
.2	1.3839	.07033	0.09733	3.3178	.42886	.23335	0.66221
.4	1.9200	.12592	0.24177	2.2264	.47979	.28035	0.76014
.6	2.3115	.17138	0.39524	1.7384	.47884	.29793	0.77677
.8	2.6281	.20952	0.55064	1.4476	.46167	.30330	0.76497
1.0	2.8967	.24213	0.70137	1.2509	.43907	.30289	0.74196
2.0	3.8677	.35562	1.3754	0.77715	.33231	.27637	0.60868
3.0	4.5360	.42564	1.9307	0.58080	.26053	.24721	0.50774
4.0	5.0569	.47470	2.4005	0.47043	.21251	.22332	0.43583
5.0	5.4894	.51164	2.8086	0.39884	.17872	.20407	0.38279
6.0	5.8617	.54084	3.1703	0.34825	.15380	.18835	0.34215
7.0	6.1901	.56473	3.4958	0.31039	.13472	.17529	0.31001
8.0	6.4853	.58476	3.7924	0.28090	.11969	.16426	0.28395
9.0	6.7538	.60189	4.0650	0.25718	.10755	.15479	0.26234

*It will be noticed that the column headed Y_0 is the square of the transcendental $\frac{dy_0}{dx}$ calculated by M. Sarrau, multiplied by a constant factor, and that $\frac{dY_0}{dy}$ is his $\frac{d^2y_0}{dx}$ multiplied by a constant factor. See Proceedings U. S. Naval Institute (Whole No. 28, page 129).

†M. Sarrau does not calculate Y_1 or $\frac{dY_1}{dy}$.

In order to find a power of y that varies approximately as Y_1 we can proceed as shown before.

Let $$Hy^\gamma = Y_1.$$

To find γ for the whole length of bore, assume $y = .1$ and $y = 9$.

Then $$H(.1)^\gamma = .98851 = Y_1 \text{ for } y = .1,$$
$$H(9.)^\gamma = 6.7538 = Y_1 \text{ for } y = 9.$$

Dividing the second by the first,

$$(90)^\gamma = \frac{6.7538}{.98851},$$

$$\therefore \quad \gamma = \frac{\log 6.7538 - \log .98851}{\log 90} = .426,$$

or $Y_1 = Hy^{.426}$, approximately, for the whole length of bore. Sarrau, as before stated, assumes $\gamma = \frac{1}{2}$.

Between $y = .1$ and $y = .2$, $Y_1 \propto y^{.4854}$.
" $y = .1$ and $y = 4.0$, $Y_1 \propto y^{.4425}$.
" $y = 4.0$ and $y = 5.0$, $Y_1 \propto y^{.3679}$.
" $y = 5.0$ and $y = 6.0$, $Y_1 \propto y^{.36006}$.
" $y = 6.0$ and $y = 7$, $Y_1 \propto y^{.3535}$.
" $y = 7.0$ and $y = 8$, $Y_1 \propto y^{.3488}$.
" $y = 8.0$ and $y = 9$, $Y_1 \propto y^{.3443}$.

These powers of y, by using first and second differences (of the exponents), enable us to calculate Y_1 for all the fractional values of y between these limits, without the use of Legendre's tables.

The following table contains the values of $\log Y_1$ and $\log Y_0$ at each tenth, between $y = 4$, and $y = 9$:

TABLE II.

y.	Log Y_1.	Diff.	Log $\left(1-\frac{1}{(y+1)^{\frac{2}{3}}}\right)$	Log Y_0.	Diff.
4.0	.70388	.00398	9.67642–10	.38030	.00775
4.1	.70786	387	9.68019	.38805	751
4.2	.71173	377	9.68383	.39556	729
4.3	.71550	368	9.68735	.40285	708
4.4	.71918	360	9.69075	.40993	688
4.5	.72278	351	9.69403	.41681	669
4.6	.72629	342	9.69721	.42350	650
4.7	.72971	334	9.70029	.43000	632
4.8	.73305	327	9.70327	.43632	617
4.9	.73632	320	9.70617	.44249	600
5.0	.73952	313	9.70897	.44849	585
5.1	.74265	306	9.71169	.45434	571
5.2	.74571	300	9.71434	.46005	556
5.3	.74871	294	9.71690	.46561	544
5.4	.75165	287	9.71940	.47105	530
5.5	.75452	281	9.72183	.47635	518
5.6	.75733	275	9.72420	.48153	505
5.7	.76008	270	9.72650	.48658	495
5.8	.76278	265	9.72875	.49153	483
5.9	.76543	260	9.73093	.49636	474
6.0	.76803	256	9.73307	.50110	464
6.1	.77059	252	9.73515	.50574	455
6.2	.77311	247	9.73718	.51029	446
6.3	.77558	243	9.73917	.51475	435
6.4	.77801	239	9.74109	.51910	429
6.5	.78040	234	9.74299	.52339	419
6.6	.78274	230	9.74484	.52758	411
6.7	.78504	226	9.74665	.53169	403
6.8	.78730	222	9.74842	.53572	394
6.9	.78952	218	9.75014	.53966	388
7.0	.79170	215	9.75184	.54354	381
7.1	.79385	212	9.75350	.54735	373
7.2	.79597	209	9.75511	.55108	368
7.3	.79806	206	9.75670	.55476	362
7.4	.80012	204	9.75826	.55838	356
7.5	.80216	201	9.75978	.56194	351
7.6	.80417	198	9.76128	.56545	344
7.7	.80615	195	9.76274	.56889	339
7.8	.80810	193	9.76418	.57228	334
7.9	.81003	190	9.76559	.57562	329
8.0	.81193	187	9.76698	.57891	322
8.1	.81380	184	9.76833	.58213	318
8.2	.81564	182	9.76967	.58531	312
8.3	.81746	180	9.77097	.58843	309
8.4	.81926	178	9.77226	.59152	305
8.5	.82104	175	9.77353	.59457	299
8.6	.82279	173	9.77477	.59756	294
8.7	.82452	170	9.77598	.60050	290
8.8	.82622	168	9.77718	.60340	286
8.9	.82790	165	9.77836	.60626	280
9.0	.82955	163	9.77951	.60906	275

Resuming equation (12), and substituting for K its value

$$\frac{1}{\tau}\left(\frac{mL}{5\omega P_0}\right)^{\frac{1}{2}},$$

for m its value $\frac{p}{g}$, and for ω its value $\frac{\pi c^2}{4}$, joining all constants in one when possible,

$$v^2 = M\frac{faW}{\tau c}\left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0\left[1 - N\frac{\lambda}{\tau c}(pL)^{\frac{1}{2}} Y_1 + N^2\frac{\mu}{\tau^2 c^2} pL\, Y_1^2\right], \quad (19)$$

which is the general formula, using the numbers in the preceding table. For a practical working formula, $M\frac{fa}{\tau}$ and $N\frac{\lambda}{\tau}$ must be determined by firing the same powder in two dissimilar guns. In the case of the pierced cylindrical grain $\mu = 0$, and the third term disappears. In the case of the sphere, or cube, $\lambda = 1$, $\mu = \frac{1}{3}$; the quantity inside the parenthesis in (19) is very nearly a perfect square, and the equation for v (equation 20) can be used with more accuracy than can (19), if only two terms are employed. In the case of the pierced prism there is probably a small third term which can be determined experimentally by a third firing, or the velocity can be determined with two firings very accurately either by (19) using two terms, or its square root, which is

$$v = M_1\left(\frac{fa}{\tau}\right)^{\frac{1}{2}}\left(\frac{W}{c}\right)^{\frac{1}{2}}\left(\frac{L}{p}\right)^{\frac{1}{4}} Y_0^{\frac{1}{2}}\left[1 - N_1\frac{\lambda}{\tau}\frac{(pL)^{\frac{1}{2}}}{c} Y_1\right], \quad (20)$$

M_1 and N_1 being the new constants.

Pressures.—Differentiating (19),

$$P = \frac{m}{\omega}\frac{d^2u}{dt^2} = \frac{4p}{\pi c^2 g}\cdot\frac{d(v^2)}{2du} = \frac{2p\,d(v^2)}{\pi c^2 g L\, dy}$$

$$= \frac{2p}{\pi c^2 g L}\cdot M\frac{faW}{\tau c}\left(\frac{L}{p}\right)^{\frac{1}{2}}\frac{dY_0}{dy}\left[1 - N\frac{\lambda}{\tau}\frac{(pL)^{\frac{1}{2}}}{c} Y_1 + N^2\frac{\mu}{\tau^2}\frac{pL}{c^2} Y_1^2\right]$$

$$- \frac{2p}{\pi c^2 g L}\cdot M\frac{faW}{\tau c}\left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0\left[N\frac{\lambda}{\tau}\frac{(pL)^{\frac{1}{2}}}{c}\frac{dY_1}{dy} - 2N^2\frac{\mu}{\tau^2}\frac{pL}{c^2} Y_1\frac{dY_1}{dy}\right] \quad (21)$$

in which the constants are known from the velocity formula (19).

Equation (21) is the general equation for the pressure per unit cross section of the base of the projectile.

In case $\lambda = 0$ and $\mu = 0$, or when all the terms of (21) except the first are so small that they may be neglected, (21) becomes

$$P = \frac{2p}{\pi c^2 g L}\cdot M\frac{faW}{\tau c}\left(\frac{L}{p}\right)^{\frac{1}{2}}\frac{dY_0}{dy}. \quad (22)$$

This is directly reducible to M. Sarrau's formula for maximum pressure. By reference to the tables, $\frac{dY_0}{dy}$ is found to be a maximum when $y = .6$. If then we only use one term for P as in (22), P is maximum at the same point (where $y = .6$). $\frac{dY_0}{dy}$ is .776 at this point. Substituting the value of $\frac{dY_0}{dy}$ in (22), and for L,

$$\frac{W\delta}{4\omega\Delta^2} = \frac{W\delta}{\pi c^2 \Delta^2},$$

and combining all constants in one, G, placing $\delta^{\frac{1}{2}}$ in the constant, we have

$$P = G\frac{fa}{\tau}\Delta\frac{(pW)^{\frac{1}{2}}}{c^2}, \qquad (23)$$

which is M. Sarrau's formula.

The pressure on the breech-block is evidently somewhat greater than the effective* pressure on the projectile, as the powder gases are in motion at the instant of maximum pressure, and have a weight not to be neglected. The pressure due to the mean acceleration of these gases as well as that due to the acceleration of the projectile, and the pressure due to forcing the projectile, as well as to rifling, are shown in the pressure recorded by a pressure gauge in the nose of the breech-block. The ratio of this latter pressure to the effective pressure evidently increases as W increases, and decreases as p increases. The ratio is evidently nearly constant when $\frac{W}{p}$ is constant. Sarrau assumes the ratio proportional to $\left(\frac{W}{p}\right)^{\frac{1}{4}}$, as he finds experimentally that

$$P_B = K\frac{fa}{\tau}\Delta\frac{p^{\frac{1}{4}}W^{\frac{1}{2}}}{c^2} \qquad (24)$$

gives very good results, P_B being the pressure per unit on the breech-block, and K a new constant.

To illustrate the working of these formulas practically it is necessary to consider the results in at least three guns. In the following calculations the rifling of the guns is not considered, nor is the resistance to forcing, except in so far as these change the constants.

The following are the actual data in the case of German cocoa powder (C_{82}), when fired in the two Navy VI-inch B. L. rifles known

*The term *effective pressure* is used in this paper to denote the pressure which causes the acceleration of the projectile.

as the South Boston gun and Dolphin's gun. All data are given in feet and pounds.

	South Boston gun.	Dolphin's gun.
Weight of charge	$= W = 29.125$ lbs.	$W = 50$ lbs.
Travel of projectile to muzzle	$= u = 10.$ feet.	$u = 11.62$ feet.
Density of loading	$= \Delta = .8763.$	$\Delta = .9886.$
Weight of projectile	$= p = 51$ lbs.	$p = 100$ lbs.
Calibre	$= c = .50$ foot.	$c = .50$ foot.
Initial velocity	$= v = 1685$ feet.	$v = 1836$ feet.

Density of powder $\delta = 1.867$.

Assuming $\mu = 0$, as it is, very nearly, in the pierced prism, and as we are using the same powder in both guns, calling $\frac{fa}{\tau}$ and $\frac{\lambda}{\tau}$ (which depend on the shape, size and material of the powder), constants, (19) becomes

$$v^2 = M' \frac{W}{c} \left(\frac{L}{p}\right)^{\frac{1}{4}} Y_0 \left[1 - N' \frac{(pL)^{\frac{1}{4}}}{c} Y_1\right], \qquad (25)$$

where M' and N' are the new constants.

In the South Boston gun (using decimeters and kilograms)

$$L = \frac{W}{\omega} \left(\frac{1}{\Delta} - \frac{1}{\delta}\right),$$

or, in feet,

$$L = \frac{29.125 \times 61.025}{3.1416 \times (3)^2 \times 2.2046 \times 12} \left(\frac{1}{.8763} - \frac{1}{1.867}\right) = 1.4388 \text{ ft.},$$

taking a liter as 61.025 cubic inches, and a kilogram as 2.2046 lbs.

Similarly in the Dolphin's gun,

$$L = 1.9413 \text{ feet.}$$

In the South Boston gun at muzzle, $y = \frac{u}{L} = \frac{10}{1.4388} = 6.9504.$

In the Dolphin's gun at muzzle, $y = \frac{u}{L} = \frac{11.62}{1.9413} = 5.9856.$

By reference to Table II it is found, by interpolation, that where $y = 6.9504$, or for the South Boston gun,

$$\log Y_0 = .54188, \text{ and } \log Y_1 = .79077;$$

and for the Dolphin's B. L. R., where $y = 5.9856$,

$$\log Y_0 = .50043, \text{ and } \log Y_1 = .76766.$$

Substituting for v, W, c, etc., their values in (25), we have for S. B. gun,

$$(1685)^2 = M' [\log^{-1} 1.53239](1 - N'[\log^{-1} 2.02458]),$$

and for Dolphin's gun,

$$(1836)^2 = M' [\log^{-1} 1.64448](1 - N'[\log^{-1} 2.21274]).$$

From these simultaneous equations we obtain

$$M' = \log^{-1} 4.98252 = 96055,$$

and $$N' = \log^{-1} (7.09757-10) = .0012519.$$

Consequently for C_{82} powder in *any* gun (25) becomes

$$v^2 = [\lg^{-1} 4.98252] \frac{W}{c} \left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0 \left(1 - [\lg^{-1} 7.09751] \frac{(pL)^{\frac{1}{2}}}{c} Y_1\right). \quad (26)$$

To verify this equation in the VIII-inch B. L. R.: In the VIII-inch B. L. R., using its full charge of 125 lbs.,

$W = 125$ lbs.

$u = 16.41$ feet.

$\Delta = .9048$.

$p = 250$ lbs.

$c = .66667$ foot.

$v = ?$.

Proceeding as before, $L = 3.2673$ feet,

$$y = \frac{u}{L} = \frac{16.41}{3.2673} = 5.0225.$$

From Table II, $Y_0 = \log^{-1} .44942$,

$Y_1 = \log^{-1} .74023$.

Substituting these values in the above equation (26), muzzle velocity $= v = 2022$ feet, in the VIII-in. B. L. R.

If we take equation (20) and call $M_1 \left(\frac{fa}{\tau}\right)^{\frac{1}{2}}$ and $N_1 \frac{\lambda}{\tau}$, M_1' and N_1',

$$v = M_1' \left(\frac{W}{c}\right)^{\frac{1}{2}} \left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0^{\frac{1}{2}} \left[1 - N_1' \frac{(pL)^{\frac{1}{2}}}{c} Y_1\right],$$

whence in S. B. gun and Dolphin's gun,

$$1685 = M_1' [\log^{-1} .76620](1 - N_1' [\log^{-1} 2.02458]),$$

and $$1836 = M_1' [\log^{-1} .82224](1 - N_1' [\log^{-1} 2.21274].$$

Finding M_1' and N_1' as before, we have for any gun,

$$v = [\lg^{-1} 2.49305] \left(\frac{W}{c}\right)^{\frac{1}{2}} \left(\frac{L}{p}\right)^{\frac{1}{2}} Y_0^{\frac{1}{2}} \left(1 - [\lg^{-1} 6.83519] \frac{(pL)^{\frac{1}{2}}}{c} Y_1\right), \quad (27)$$

and substituting the values of W, c, L, p, Y_0 and Y_1 for the VIII-inch B. L. R., we have $v = 2028$ feet.

125 lbs. of C_{82} powder have never been fired in the VIII-inch B. L. R., but 122 lbs. have. Three rounds with 122 lbs. of German cocoa powder, using a 250-lb. projectile, gave muzzle velocities of 1996, 1996 and 2006, or a mean muzzle velocity of 1999. Any of

the ordinary empirical rules for muzzle velocity will answer nearly enough for such a small change as from 122 lbs. to 125 lbs. of powder.

The rule that in the same gun the muzzle velocity varies as the $\frac{6}{10}$ power of weight of charge gives for 125 lbs. of powder, in VIII-inch B. L. R., $v = 2029$ f. s. The $\frac{6}{10}$ rule gives 2028.

In the VI-inch (Dolphin's gun), when the charge is 58 lbs., the velocity is 2000 f. s.; when the charge is 50 lbs. the velocity is 1835 f. s. In this gun the velocity evidently varies as the .58 power of the weight of charge; and if this power holds, as it evidently will very approximately, in the VIII-inch, the muzzle velocity would be 2027 f. s.

Either $v = 2022$, or $v = 2028$, as deduced from the formulæ (26) and (27), is within the limit of accuracy of the chronograph reading.

By Sarrau's formula (15), using exactly the same data, the muzzle velocity in the VIII-inch B. L. R. is 2041 f. s. (See Interior Ballistics, by Lieuts. J. F. Meigs and R. R. Ingersoll, page 91.)

Pressures.—The effective pressure on the base of the projectile is readily found, assuming equation (26).

Equation (26) becomes for the three guns under consideration, substituting for W, c, L and p their values,

for South Boston VI-inch,

$$v^2 = [\log^{-1} 5.97303]\ Y_0 (1 - [\log^{-1} 8.33132]\ Y_1);$$

for Dolphin's VI-inch,

$$v^2 = [\log^{-1} 6.12657]\ Y_0 (1 - [\log^{-1} 8.54259]\ Y_1);$$

for VIII-inch B. L. R.,

$$v^2 = [\log^{-1} 6.31365]\ Y_0 (1 - [\log 8.72967]\ Y_1).$$

The effective pressure on the base of the shot is $\frac{md(v^2)}{2du}$, and the effective pressure per *square inch* is $\frac{md(v^2)}{2\omega du}$, taking ω in square inches;

$$\therefore\ P = \frac{md(v^2)}{2\omega du} = \frac{4pd(v^2)}{2\pi c^2 g du} = \frac{2p}{\pi c^2 g L} \cdot \frac{d(v^2)}{dy},$$

where c is in inches.

Differentiating the three equations for v^2 above;—in S. B. gun,

$$\frac{d(v^2)}{dy} = [\log^{-1} 5.97303] \frac{dY_0}{dy} - [\log^{-1} 4.30435]\ Y_1 \frac{dY_0}{dy} - [\log^{-1} 4.30435]\ Y_0 \frac{dY_1}{dy};$$

in Dolphin's gun, $\frac{d(v^2)}{dy} = [\log^{-1} 6.12657] \frac{dY_0}{dy}$

$$- [\log^{-1} 4.66916]\ Y_1 \frac{dY_0}{dy} - [\log^{-1} 4.66916]\ Y_0 \frac{dY_1}{dy};$$

in VIII-inch, $\frac{d(v^2)}{dy} = [\log^{-1} 6.31365] \frac{dY_0}{dy}$

$$- [\log^{-1} 5.04332] Y_1 \frac{dY_0}{dy} - [\log^{-1} 5.04232] Y_0 \frac{dY_1}{dy}.$$

Calling g 32.2, and substituting for p, π, c, g and L their values, we have,

in South Boston gun,

$$P = [\log^{-1} 8.29930] \frac{d(v^2)}{dy};$$

in Dolphin's gun, $P = [\log^{-1} 8.45162] \frac{d(v^2)}{dy}$;

in VIII-inch, $P = [\log^{-1} 8.37359] \frac{d(v^2)}{dy}$;

and the final values of P, the effective pressure per square inch on the base of the projectile, are, in the South Boston VI-inch B. L. R.,

$P = [\log^{-1} 4.27233] \frac{dY_0}{dy}$

$$- [\log^{-1} 2.60365] Y_1 \frac{dY_0}{dy} - [\log^{-1} 2.60365] Y_0 \frac{dY_1}{dy};$$

in the Dolphin's VI-inch B. L. R.,

$P = [\log^{-1} 4.57819] \frac{dY_0}{dy}$

$$- [\log^{-1} 3.12078] Y_1 \frac{dY_0}{dy} - [\log^{-1} 3.12078] Y_0 \frac{dY_1}{dy},$$

and in the VIII-inch B. L. R.,

$P = [\log^{-1} 4.68724] \frac{dY_0}{dy}$

$$- [\log^{-1} 3.41691] Y_1 \frac{dY_0}{dy} - [\log^{-1} 3.41691] Y_0 \frac{dY_1}{dy}.$$

The following table, compiled from Table I, will be of use:

TABLE III.

y.	$\log\left(\frac{dY_0}{dy}\right) + 10$.	$\log\left(Y_1 \frac{dY_0}{dy}\right)$.	$\log\left(Y_0 \frac{dY_1}{dy}\right)$.
0.1	9.72174	9.71672–10	9.25241–10
.2	9.82100	9.96211–10	9.50910–10
.4	9.88089	0.16419	9.73102–10
.6	9.89029	.25419	9.83701–10
.8	9.88364	.30329	9.90152–10
1.0	9.87038	.33229	9.94318–10
2.0	9.78439	.37184	0.02894
3.0	9.70564	.36231	.04974
4.0	9.63932	.34320	.05280
5.0	9.58296	.32248	.04929
6.0	9.53422	.30225	.04299
7.0	9.49137	.28307	.03546

The following calculation will illustrate the method of procedure in each case:

Effective pressure in the South Boston gun when $y = .6$,

or $u = Ly = 1.4388 \times .6 = .86328$ feet.

$\frac{dY_0}{dy}$	log 9.89029	$Y_1 \frac{dY_0}{dy}$	log 0.25419	$Y_0 \frac{dY_1}{dy}$	9.83701
	4.27233		2.60365		2.60365
14542	log 4.16262	721	log 2.85784	275	log 2.44066
966		275			
		996			

$P = 13546$ lbs. per sq. inch.

Proceeding in the same way for all three guns, we obtain the following table of effective pressures per square inch on the base of the projectile:

	South Boston VI-in. B.L.R.		VI-in. B.L.R. (Dolphin).		VIII-in. B. L. R.	
y.	u (feet).	P (lbs.).	u (feet).	P (lbs.).	u (feet).	P (lbs.).
.1	.144	9583	...	...	...	...
.2	.29	11900	.39	23435	0.65	28991
.4	.58	13429	.78	26142	1.3	31777
.6	.86	13546	1.16	26130	1.96	31319
.8	1.15	13194	...	...	2.61	29897
1.0	1.44	12675	...	...	3.27	28205
2.0	2.88	10021	...	...	6.53	20683
3.0	4.32	8131	5.82	14701	9.80	15768
4.0	5.76	6821	...	...	13.06	12506
5.0	7.19	5873	...	...	16.33	10217
6.0	8.63	5159	11.62	8847	...	...
7.0	10.00	4598	...	...	...	...

Resuming the muzzle velocity formula of M. Sarrau, equation (15), placing $\frac{fa}{\tau}$ and $\frac{\lambda}{\tau}$ in the constants, the formula for muzzle velocity, using any fixed powder, becomes

$$v = A_1 (Wu)^{\frac{1}{3}} \left(\frac{\Delta}{pc}\right)^{\frac{1}{3}} \left[1 - B_1 \frac{(pu)^{\frac{1}{2}}}{c}\right].$$

If the gun remains the same, as well as the weight of charge and projectile, the equation can be still further simplified to

$$v = A_2 u^{\frac{1}{3}} [1 - B_2 u^{\frac{1}{2}}].$$

This is true for ordinary muzzle values of y or $\frac{u}{L}$. The part inside brackets, or $1 - B_2 u^{\frac{1}{2}}$, is very approximately true for the whole

length of bore. The part outside is true only for muzzle distances. If we substitute for $A_2 u^{\frac{3}{4}}$, $M_2 Y_0^{\frac{1}{2}}$, the velocity formula will be very approximately true for the whole length of bore.

For any point, then, in the travel of the projectile inside a gun, $v = M_2 Y_0^{\frac{1}{2}} (1 - B_2 u^{\frac{1}{2}})$, M_2 being determined by the condition that $M_2 = \frac{A_2 u^{\frac{3}{4}}}{Y_0^{\frac{1}{2}}}$ at the muzzle of the gun.

Squaring, $v^2 = M_2^2 Y_0 (1 - B_2 u^{\frac{1}{2}})^2$. Consequently, for the pressure at any point we have

$$P = \frac{m}{\omega} \frac{d(v^2)}{2du} = \frac{2p}{g\pi c^2} \frac{d(v^2)}{du}$$

$$= \left[(1 - B_2 u^{\frac{1}{2}})^2 \frac{M_2^2}{L} \frac{dY_0}{dy} - M_2^2 Y_0 (1 - B_2 u^{\frac{1}{2}}) \frac{B_2}{u^{\frac{1}{2}}} \right] \frac{2p}{g\pi c^2},$$

or $$P = \frac{2p}{g\pi c^2} M_2^2 (1 - B_2 u^{\frac{1}{2}}) \left[(1 - B_2 u^{\frac{1}{2}}) \frac{dY_0}{L dy} - \frac{B_2 Y_0}{u^{\frac{1}{2}}} \right].$$

This formula will give pressures similar to those already obtained. The pressures calculated by any of these different formulæ will determine a pressure curve, the area of which will necessarily agree exactly with the muzzle energy of the projectile, as determined from the corresponding velocity formula.

The pressure formula deduced from (27) gives pressures a little higher at the muzzle and correspondingly decreased at the breech of the gun. It is probably a little closer the truth than the first. As calculated by the first formula, the maximum effective pressure on the base of the projectile is 32,000 lbs. in the VIII-inch B. L. R., and 26,200 lbs. in the VI-inch B. L. R. (Dolphin's gun). The maximum pressure in the VIII-inch B. L. R. with 122 lbs. C_{82}, as measured by a crusher gauge, was 15.2 tons. For 125 lbs. of the same powder it should be 35,500 lbs. The difference between 35,500 and 32,000, or 3500 lbs., seems hardly large enough when we remember that the charge is one half the weight of the projectile, and that all of it is probably in motion at the instant of maximum pressure, with a mean velocity and mean acceleration equal probably at least to $\frac{1}{3}$ that of the projectile. The maximum effective pressure would then be in the neighborhood of 30,000 lbs. Likewise for the VI-inch B. L. R. (Dolphin). The recorded maximum pressure determined from the mean of 10 rounds in the VI-inch, Mark II. (which has a chamber very slightly larger than the Dolphin's gun), using 53¼ lbs. of C_{82} powder, was 13.9 tons. The pressure for 50 lbs. in the same gun

would then be 27,900 lbs., or, in the Dolphin's gun, 28,000 lbs. in round numbers. The difference, 1800 lbs., between this and the effective pressure, 26,200 lbs., as in the VIII-inch B. L. R., is probably about one half of what it should be. The recorded pressure in the South Boston gun was 12,100 lbs. This is lower than the calculated maximum effective pressure, which is 13,500 lbs. The ordinary empirical formulæ for maximum pressures, using the data furnished by the VI-inch B. L. R. (Mark II.), or the VIII-inch B. L. R., give in the S. B. gun a pressure on the breech-block of about 14,500 lbs.

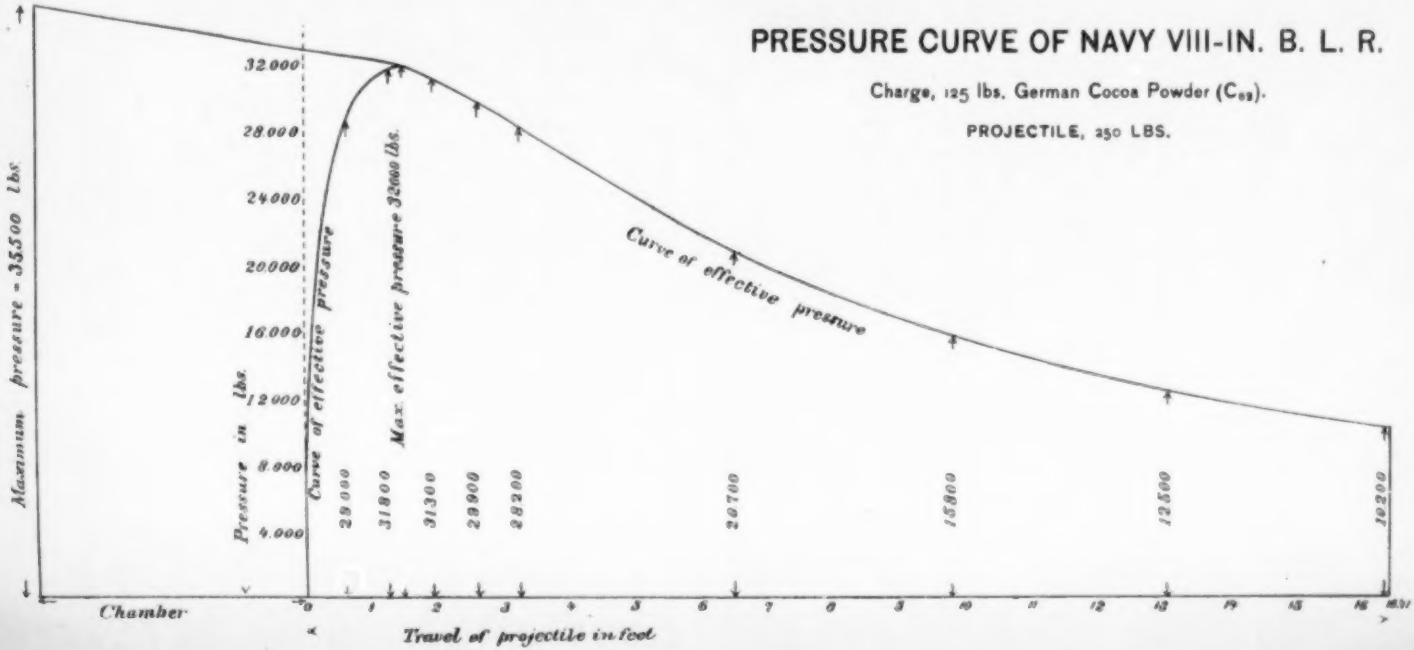
It is possible that the quantity n, assumed as 1.4 in calculating the tables in this paper, is not exact. Also that the velocity of combustion of powder does not vary exactly as the square root of the pressure. The character of the rifling and the form of the powder chamber, the forcing of the projectile, etc., also play a more or less important part. The volume of the solid residue of powder is not exactly equal to the volume of the powder. It may then be argued that the results obtained are certainly very fair. There is, however, no reason to suppose that the exact formula for velocity as deduced (19) is more accurate (or even as accurate) than the slightly empirical formula (15), obtained, in this paper, from it, and which has been demonstrated by a large number of firings to agree very closely with experiment.

In any gun, the pressure curve should be calculated from the velocity formula which gives the best actual results for velocity. The effect of rifling is to increase the subtractive term in the velocity formula as y increases, according to some power of y. It is possible then that the second term in brackets may vary not only as $y^{\frac{1}{2}}$, but in some cases even in excess of this power. To obtain the pressure upon the walls of the gun at any point, the pressure necessary to accelerate the rotation of the projectile and to overcome friction must be added to the effective pressure at the same point.

PRESSURE CURVE OF NAVY VIII-IN. B. L. R.

Charge, 125 lbs. German Cocoa Powder (C_{82}).

PROJECTILE, 250 LBS.



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U. S. NAVAL INSTITUTE, ANNAPOLIS, MD.

IGNITION OF EXPLOSIVE MIXTURES OF GASES BY BROKEN INCANDESCENT LAMPS.

EXPERIMENTS MADE AT THE TORPEDO STATION, NEWPORT, R. I.

BY LIEUTENANT HAMILTON HUTCHINS, U. S. N.

The behavior of incandescent lamps in explosive gases is of considerable importance in the present days of electric lighting. It is important as regards safety on board ship, and it is even more important in connection with lighting mines by electricity. I think heretofore it has been the popular opinion, at least in this country, that on breaking an incandescent lamp bulb in an explosive gas, the filament would be broken before the gas could become ignited and that thus there is no danger to be apprehended.

A great many experiments have been made by people at different times in connection with this subject, but most of them are incomplete, owing to the fact that they do not take into consideration the fact that the gases must be mixed in proportions known to be explosive.

In an extract from the *Electrical Review*, February 18, 1888, on the "possibility of ignition from incandescent lamp filaments," is quoted: "We *believe* that, under such conditions, the gas would be exploded in the event of the breakage of the lamp." This would imply that experiments were still wanting to settle this question.

I have been engaged at intervals during the past six months with experiments to determine "whether or not incandescent lights may under some circumstances be dangerous to ship lighting," and made the following report (January 20, 1888) to the Inspector of Ordnance in charge of the Torpedo Station:

Experiment No. 1.—By means of a station battery and a water voltameter a sufficient amount of hydrogen and oxygen was col-

lected to about fill an exercise gunpowder torpedo case. The fittings to the case were as follows: An entrance at the side to admit a steel rod for piercing the bulb, a window to ascertain whether or not the lamp was burning, and a wooden frame to hold the lamp, the latter being inserted at the lower end of the case, which was open and under water. The explosion of a mixture of hydrogen and oxygen being violent, the case was lashed down so it would not have to be held in position. A Swan lamp of 16 c. p. was used in this experiment, the carbon filament was raised to a white incandescence from a dynamo, and the lamp in its frame introduced into the case containing the explosive gas. The bulb was then pierced. The gas exploded immediately with considerable noise, completely shattering the lamp bulb but not bursting the tin case. The carbon filament remained intact, probably due to the fact that the glass bulb was shattered into an innumerable number of small pieces. From this experiment two points are evident:

1. That the inrush of gas does not break the Swan filament before the gas can become ignited; and

2. That in a highly explosive gas the breaking of an incandescent lamp would be dangerous, at least with a filament not less delicate than that in the Swan lamp.

Experiment No. 2.—Marsh gas is said to detonate when mixed with air in the proportion of one volume of the gas to seven and a half volumes of air. The gas mixed in the above proportions was collected in a case similar to that used in experiment No. 1. The same kind of lamp was used and the experiment conducted in a manner similar to the preceding. The gas did not explode. The filament was found to be broken, due of course to the flying pieces of glass.

Experiment No. 3.—Coal gas alone was used in this experiment, simply to observe the effect. The experiment was conducted in a manner similar to the preceding ones, except that a Maxim lamp was used. The result on piercing the bulb was that the filament continued to burn, the gas probably being decomposed, and carbon deposited on the filament in a manner similar to that in the "flashing test" in the manufacture of incandescent lamps.

Experiment No. 4.—In this experiment coal gas was used mixed with air in the proportion of one volume of the gas to six volumes of air. A Maxim lamp was used and the experiment conducted in a manner similar to the preceding ones, except that a pressure gauge

was used to make certain whether or not the gas exploded, for this gas being a weak explosive, the noise of the explosion might be faint.

On piercing the bulb, the filament not having been broken by the inrush of gas nor by flying pieces of glass, the lamp continued to burn for a few seconds; then, the required temperature being apparently reached, the gas exploded, making quite a noise. The tin case not being lashed down in this experiment, was lifted five or six feet in the air and the filament then broken from the shock of the explosion. It is considered unnecessary to experiment further with marsh gas, as the latter is even more explosive than coal gas.

As a result of these experiments it is clear that the incandescent filament (provided it is as tough as either the Swan or the Maxim filaments) coming in contact with either a highly explosive gas such as a mixture of hydrogen and oxygen, or a comparatively weak one such as coal gas and air in explosive proportions, will explode them.

I am of the opinion, therefore, that when explosive gases are allowed to collect on board ship from bad ventilation or other causes, incandescent lights such as were used in these experiments are dangerous to ship lighting.

Other experiments could no doubt be made that would be interesting and perhaps valuable in connection with this subject. For instance, it is claimed for the Edison lamp that the filament is always broken by the first inrush of gas. If this be true, there would appear to be more safety with the Edison lamp for ships' use.

In connection with the first experiment,* I would state that the precaution was taken to carefully solder the leads to the springs in the Swan socket, for otherwise an arc or spark might be formed which would explode the gas and that would be misleading.

Since the above experiments were made I received a communication from W. E. Peters, civil and mining engineer at Athens, Ohio, enclosing an extract from the Transactions of the "Mining Institute of Scotland," Vol. III, pp. 145–155. This extract describes an experiment made at Earnock Colliery, Hamilton, August 11, 1881, in the presence of Mr. Andrew Jamieson, C. E., Principal of the College of Science and Arts, and about 100 members of the Institute. The experiment was to ascertain whether Swan's lamp would explode gas if it were broken in a mixture of inflammable gas. "For this purpose a box 15 inches square and 2 feet deep was suspended from

* In the first experiment I am indebted to Ensign Denfeld, U. S. N., for his valuable assistance.

the roof enclosing a Swan lamp, and containing a pane of glass on one side, through which the lamp was seen burning. The box was filled with coal gas until it reached the explosive point, which was ascertained by the insertion into the box of a Davy lamp. The crucial step in the experiment was then taken, the glass globe within which the incandescence is carried on, *in vacuo*, being broken, when immediately the gas inside the box was ignited and exploded. This was taken as conclusive, as Mr. Jamieson has previously admitted, on the point as to the Swan lamp only being safe so long as it remains intact. The illuminating power of this lamp was about 15 candles."

This would seem to corroborate my experience so far as the Swan lamp is concerned, provided they took the precaution to connect the lamp leads so as to prevent by any possibility an arc or spark being formed at the springs in the base of the Swan socket which might explode the gas.

Experiments Made in the Physical Laboratory, U. S. Naval Academy, by Professor N. M. Terry, Ph.D., and Lieutenant T. B. Howard, U. S. N.

The socket of an Edison 16 c. p. lamp was fixed to a block in a cubical box of about one cubic foot capacity, so that when the lamp was inserted it would be near the centre of the box. Paper was pasted over the top of the box, and the mixtures, generally of coal gas and air in different proportions, were introduced through a stop-cock in the side of the box, the air being forced out through another stop-cock. After the air had been displaced by the mixed gases the current from the dynamo was turned on, and the light from the glowing lamp could be seen through the translucent paper cover. By means of a large wooden screw passing through one side of the box the lamp was pressed between the end of the screw and a block of wood on the opposite side until it broke. A loud explosion immediately followed, and the paper cover was torn and thrown about the room. The lamp was shattered and the carbon filament broken into pieces. As the lamp was burning safely in the explosive mixture until it was broken by the screw, it is evident that the gases were not ignited by any spark or arc across an imperfect contact in the socket or leading wires, but by the contact of the mixed gases with the glowing carbon. A fuller account of the experiments may be found in a report made to the Superintendent of the Naval Academy, December 8, 1887.

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U. S. NAVAL INSTITUTE, NEWPORT BRANCH,

APRIL, 1888.

NOTES ON THE LITERATURE OF EXPLOSIVES.*

BY CHARLES E. MUNROE.

No. XVII.

We are in receipt of a pamphlet entitled "The Graydon Dynamite Projectile High Explosive and Accelerated Cartridge," from which we learn that the experiments made at Sandy Hook, which were described in No. XVI of these Notes,† were carried out under the Graydon system.‡ The pamphlet contains three cuts showing the target before and after the experiments and one of the shells which struck "point on." The target, according to the cut, was a section of a monitor turret in service condition, lacking only the support which the completed cylinder gives. We should judge from the appearance of the shell, if the artist has represented it correctly, that the explosive did not undergo complete detonation.

Captain Zalinski having criticised the results of these experiments adversely, he was met by a letter from W. W. Dudley, general manager of the Graydon Dynamite Company, which was published in the Washington *Post* of February 27, 1888, and in which exceptions were taken to some of Zalinski's alleged statements. Captain Zalinski's reply to this appears in the Washington *Capital* of March 4, 1888, and the New York *Herald* of the same date. We have not

* As it is proposed to continue these Notes from time to time, authors, publishers, and manufacturers will do the writer a favor by sending him copies of their papers, publications, or trade circulars. *Address Torpedo Station, Newport, R. I.*

† Proc. Nav. Inst. 14, 156–158; 1888. ‡ Ibid. 13, 412–413; 1887.

seen the first two statements, but have been supplied with copies of the last two. In the *Capital* Captain Zalinski says:

"The Graydon system has thrown but very small charges of high explosives, and cannot throw very much larger ones successfully, 'with full powder charges.' It can hardly, therefore, be considered in the same category as the Pneumatic Torpedo Gun system, which has already thrown shell containing 100-pound charges of explosive gelatine and dynamite No. 1, and will, within a very few weeks, throw charges of 600 pounds.

"But as a proof of the substantial correctness of my statements, the following is given as a summary of the *last* Graydon experiments at Sandy Hook.

"Experimental firing with shells charged with dynamite by Graydon's method were made by the Ordnance Board, U. S. A., at Sandy Hook, on December 1, 1887, under supervision of Mr. Graydon, to obtain penetration of armor. A delayed action percussion fuze was used. Seven shots were fired from a 7-inch M. L. rifle; weight of charge 23 pounds, weight of loaded shell 122 pounds, weight of dynamite in shell about 2¼ pounds. The target was a section of a wrought iron turret 14 inches thick, composed of two 7-inch layers which had been considerably damaged in former experiments. It was placed 100 yards from the gun. The first shot fired, without fuze, exploded violently upon striking target. All the other shells were provided with fuzes; the second deepened the indentation about 2 inches, and the third about 4 inches. The fourth and fifth shots were fired at a wooden target about a mile distant; the fourth burst prematurely in the air, the fifth burst upon striking. The sixth and seventh shots were fired at sea; the flight of the sixth was very irregular, it probably failed to take the grooves. It did not burst upon striking the water. The seventh burst prematurely in the air. To demonstrate the safety in handling shots were fired from a Springfield rifle at a can filled with the prepared dynamite. It blew up at the third shot.

"In the experiments preceding the ones of which very partial and incomplete extracts of the board are given in Graydon's pamphlet, a gun *was burst* in the attempt to fire one of the Graydon shells. This can be substantiated by reference to official reports. There is also quite authentic information that at *least* one gun has been burst by Graydon in European experiments.

"It will be noted that in all the quotations made from reports of

boards no mention is made of the fact that a gun had been burst at Sandy Hook. This may, however, appear to be a very trifling matter. It may be well to analyze the recent Sandy Hook experiments, upon which so much stress is laid, and see what has been accomplished. The weight of shell thrown was 122 pounds. The charge of dynamite claimed was 2¾ pounds. There is reason to suppose that the charge of *dynamite* was really less, but it is too small a matter to discuss further. But the dynamite thrown was only a 60 per cent dynamite. Now, in speaking of dynamite for military purposes, No. 1 dynamite, containing 75 per cent of nitro-glycerine, is supposed to be referred to. The 60 per cent dynamite is less effective by 20 per cent than the No. 1 dynamite, and also much less sensitive to shock. Being tested in cold weather (December), may also be a factor to consider, in view of the ease with which it congeals, and its reduced sensitiveness and efficacy when in a congealed state. This charge of 2¾ pounds is a trifle more than 2 per cent of the total weight of the shell. Whatever its effect might be if the shell had really penetrated armor, its effect would certainly be nil as a *torpedo*. On the other hand, the shell of the Pneumatic Torpedo Gun carries a charge of the highest grade of high explosives of from 60 per cent to 200 per cent of the weight of the shell. In other words, the charges its shell will convey are from 100 pounds up to 600 pounds of explosive gelatine. Comparing simply the charges actually thrown, we have a record of shells fired carrying a charge of 100 pounds of explosive gelatine, equivalent to at least 166 pounds of Mr. Graydon's 60 per cent dynamite, or more than sixty times as much. The larger charges thrown by the Pneumatic Torpedo Gun must be effective for torpedo action against the under-water hull, and this is the main point claimed. But, if properly exploded, they will not be innocuous when striking the over-water hull.

"It is obvious that Mr. Graydon has done nothing to approach this, and cannot, therefore, claim to come within the same field. The full official reports will show that several of the Graydon shells *did* burst near the muzzle and some distance therefrom *whilst in the air*. Let us now examine the claims as to penetration of the target and the character of the injuries done thereto. The target, as stated by Graydon, consisted of two layers of 7-inch wrought iron plates bolted together. This is very far, in its resisting capabilities, from a 14-inch plate. The illustrated pamphlet, published also by Graydon, shows that these, which were bent in a semicircular form, simply stood,

unsupported at front or rear, on some planking. They weighed, at most, 120 tons. The Graydon shell, weighing 122 pounds, if fired 'with full powder charges,' should have attained a velocity of not less than 1300 feet per second. This should give an energy of at least 1400 tons. The 7-inch shell, *without any bursting charge*, should have obtained a *penetration* of at *least nine* inches. The utmost penetration shown by the official report is only *eight* inches, and this penetration was produced by hitting in a spot where, at some previous experiments, the target had been indented from one to *three* inches. It may be well to state here that this same target had been very considerably injured by firing of shell other than the Graydon in previous experiments.

"The *penetration* produced, it is seen, is less than that due to a blank shell. As the target weighed only 120 tons and was totally unsupported against a blow of 1400 foot tons of energy, due to the shell, unaided by the explosive, it would have been very easily racked and shaken up by the first round, so that the bolts assembling the various plates would have been disrupted and the plates separated. They would not, in this condition, present much more resistance than that due to *a single unsupported 7-inch* plate. It is to be noted, also, that this plate has numerous very large bolt holes in it, which would not exist in modern armor plates; these would determine lines of weakness in the plates already well battered by previous fires.

"The shells used were probably not less than 2½ calibers long, and therefore about 17 inches in length. The maximum penetration *claimed* was only 8 inches. It will thus be seen that hardly more than the ogival point of the shell had entered the plate before explosion, and thus the explosion had taken place practically *outside* of the target. 'Penetration before explosion' can hardly be substantiated by these results, even when a portion of the indentation had not been made at a *previous* fire. Especially is this the case in view of the fact that the *blank* shell would have produced a *greater* indentation than was actually claimed for the *loaded* shell.

"The racking effect of a blow of 1400 foot tons of energy on an unsupported iron target, weighing only 120 tons, would easily snap the 1¼-inch bolts by which the top or cover plates were attached to the vertical target. The explosion of the charge ensuing probably *after* this blow had been delivered might very readily shake and lift this, weighing only 15 tons, and deposit it a few feet from the vertical

target, particularly as it is seen, from the illustrated Graydon pamphlet, that there was a marked over-hang of the turret cover.

"I will concede that a shell charged with high explosives will, in itself, produce but little injury to an iron target, unless properly exploded from the rear end, and not by simple impact. Although Graydon claimed that no explosion would ensue if his shell did not carry his fuze, explosion *did* take place in his first fire, where the shell *was* unfuzed.

"I should be pleased to think that a charge of 2½ pounds of 60 per cent dynamite could really perform the injury to a well supported target when exploding, as did the Graydon shell, on the unsupported target practically outside of the plates; I should feel more sanguine than ever of the results which a 600-pound charge of camphorated explosive gelatine would produce on striking even the heaviest armor, although this is not the objective target of the pneumatic torpedo shell.

"To summarize: The official report will show that Graydon had burst at least one gun at Sandy Hook; that he had *not penetrated* with his shell, *before explosion*, to an extent as great as would have been accomplished with a blank shell; that the injury done to the unsupported and already injured target was but little more than would have been accomplished by any equal number of rounds with similar powder gun shell; that *several* Graydon shell *did burst prematurely in the air without impact on any target;* that the percentage of the weight of high explosive thrown is insignificant when compared with the total weight of the projectile; that the sum total of the results obtained would certainly not encourage the Ordnance Department of the Army or Navy to permit the Graydon shells to be fired from their best modern high-power guns, which alone can give requisite penetration, pure and simple, against modern armor. Neither would the results as to *safety* warrant the gunners standing by the guns when fired, or make it permissible to fire these shells over the heads of troops or outlying works of the defense.

"The questions raised regarding the report of the Naval Board on the Pneumatic Torpedo Gun may be discussed at some future time and before the proper authorities.

"Very much is conceded therein without qualification, particularly as to its accuracy, safety, and applicability in harbor defense. Personally, I desire nothing better than to be able, when the Pneumatic Dynamite Torpedo Gunboat is completed, to attack an armored

vessel, of the strongest construction that modern ingenuity can give both to the under-water and over-water hull.

"For purposes of comparison of the relative *chances* of hitting, and of *efficiency* when hitting, I would have, at the same time, an attack on the target by ships carrying high-power powder guns and using Graydon's shells (if they will dare to use them) or any other kind of shells, and by torpedo boats carrying Whitehead, Howell or any other kind of torpedoes. Such a trial should simulate service conditions as nearly as possible, the attacking force at least to be in motion at full speed. If the sea is rough, so much more thoroughly will be the question of the relative *chances* of obtaining results be settled.

"The efficiency of the Pneumatic Torpedo Gun when on a fixed platform has been settled by actual trials, and is very fully conceded in the report of the board referred to by the general manager. It does not depend upon the firing of a very few shells carrying insignificant charges, nor does it have a record which would render it prudent for the gunners to get within a bomb-proof when it is fired."

The *Army and Navy Register*, March 24, 1888, states that Mr. Graydon recently filed with the Secretary of War charges against Captain Zalinski of conduct unbecoming an officer and gentleman, in that he is said to have publicly made unjust reflections upon the Graydon dynamite gun. Lieutenant Graydon asked that a court-martial be ordered for the trial of Captain Zalinski on the charges, and that the members of the Army Board of Ordnance be summoned as witnesses. Assistant Secretary Benet declined to entertain the request for a court-martial, on the ground that if Graydon's business interests have been damaged by statements made by Captain Zalinski, a military tribunal could afford him no relief. From the same journal, March 17, 1888, we learn that the House Military Committee has determined on a favorable report of the bill appropriating $10,000 for the conduct of experiments with Lieutenant Graydon's dynamite shells, and recommended that one of the old monitors be placed at his disposal for use as a target for these projectiles.

In discussing Captain Zalinski's paper on "The Naval Uses of the Pneumatic Torpedo Gun,"* we have said: "In considering the effect of the pneumatic gun projectile, it becomes evident, from the material of which it is made, the lightness of its walls, and the low velocity

* Proc. Nav. Inst. 14, 44; 1888.

with which it is propelled, that penetration is impossible. In fact, Captain Zalinski states that the shell will be crushed on impact; then the conditions which prevail tend to produce a low degree of efficiency. But to meet this criticism Captain Zalinski has devised a most ingenious hypothesis. He holds that the inertia of the explosive will act as a tamping or as a confining envelope. *This hypothesis is one which easily admits of being experimentally tested, and it is much to be regretted if Captain Zalinski has failed to do this.*"

In reply to this Captain Zalinski says:* "Had Professor Munroe carefully read some of the papers previously published on the gun experiments, and portions of which he had republished in the U. S. Naval Institute Proceedings, he would have seen that the value of a tamped charge as compared to an untamped charge had been fully recognized, and that definite experiments had been tried proving this. These experiments were made by explosions of charges suspended against iron plates, and by firing the charges from the pneumatic gun against the iron plates. The Professor misapprehends as to the arrangement of the shell. It is not intended that the part containing the charge is to be crushed on impact before explosion can take place. The electrical arrangements are such as to insure explosion before the body of the shell can be crushed. In this way the tamping effect of the encasing shell is obtained, as well as from the initial detonation taking place at the rear of the charge."

Such résumés and notices as we have made of papers relating to the gun experiments will be found in **11**, 285–293, 767–769; **12**, 616–617, and **13**, 567–573. Lest we have inadvertently done Captain Zalinski an injustice we have again carefully reviewed the sources from which these abstracts were taken, and the only experiments of the kind which we find described are in "The Pneumatic Dynamite Torpedo Gun," published in the *Jour. Mil. Serv. Inst.* **8**, 1–35; 1887. In the reprint which we possess we find on pages 9 and 10: "As soon as a suitable battery had been selected, arrangements were made to try experiments upon iron plates to determine the best details of arrangement of the charge and of fuze. The following experiments were tried:

"An iron target was constructed of plates of the English ship Nankin, sunk in the harbor and being raised by the Engineer Department. The plates were supported against the interior parade wall, and the gun was placed outside of the fort, at the sally-port, 60 yards

* Loc. cit. 14, 53; 1888.

from the target. A blank shell charged with sand, total weight 30 pounds, was fired. It penetrated three plates, aggregating 2.5 inches. A similar shell, charged with dynamite, having no fuze, intended to explode on impact, penetrated only a single plate, and its effect was actually *less* than the blank shot previously fired. Another shell fired with a detonating fuze in the front of the charge did but little more damage. An electrical fuze was then arranged so that the circuit should be closed when the body of the shell was one-eighth inch from the target. The primer was placed in the rear part of the charge. To further insure against premature explosion by simple impact, a thin layer of cotton waste was placed in front of the shell. The resulting explosion was the most effective produced; the six plates of the target, aggregating 4.5 inches, being broken through and indented in nearly a circular area of about 18 inches diameter. The stone wall in the rear was also somewhat broken by the shock.

"It was evident from the results obtained that the effect to be produced by the explosion of the dynamite shell would not be limited to simple puncturing of a target, but that it would produce cracks and breaks at points distant from the point of impact. This was shown in some experiments upon the stern-post of the Nankin, a forging about 5 inches by 8 inches cross-section. Charges of 3 pounds were exploded upon it. They simply indented the piece at the point of placement, but broke pieces of 2 feet in length at the extremities 6 feet and 8 feet distant, and produced large cracks at other points."

Again, pages 19 and 20, he says: "An experiment tried by Commander Folger, U. S. Navy, is often quoted. In this a charge of 100 pounds of dynamite was suspended against an iron target consisting of eleven one-inch plates, strongly bolted together, and backed by 20 inches of oak well braced. The result was an indentation of only about 2 inches, extending over an area of two feet. From this the conclusions are published, 'that a modern armor-clad will not receive material injury by the explosion in superficial contact with iron over-water plating of very large charges of dynamite.' The superficial contact of the charge, as exploded, did not to my mind represent the conditions at the instant of explosion of a shell from the pneumatic gun. The element of tamping was here entirely lacking. To test this matter in a small way, the following experiment was tried:* A cartridge of 8 ounces of dynamite was suspended in 'superficial contact' with an iron plate three quarters of an inch thick, and there

*Vide Proc. Nav. Inst. 13, 570; 1887.

exploded. The result was a simple indentation of the plate. A charge of 8 ounces was again suspended against the plate, but over it was loosely suspended a piece of angle iron open at both ends, and of such size that the inscribed circle between its sides and the plate was less than the cross section of the charge, which was cylindrical. Thus there was no direct pressure against the cartridge. Yet a large elliptical hole was blown through the plate considerably longer and broader than the cartridge. This experiment was repeated with almost identical results. When two plates were placed together, a hole was blown through *both* plates."

Among the appendixes to the *Annual Report of the Chief of Ordnance, U. S. A.*, soon to be published, is one prepared by Major George W. McKee, on "The Present Status of Dynamite as an Explosive for Shells." Prefacing it with a brief history of the discovery and use of nitro-glycerine, he says: "Nobel's explosive gelatine or blasting dynamite has been used in this country by United States officers, to the entire demonstration of the fact that this high explosive, contained in a shell as a bursting charge, might be fired from a gun. The ordinary blasting dynamite made by the company (some of it experimentally modified by about three per cent of camphor) was used, and enough shells were thrown from the bores of the old mutilated guns used in the experiment to demonstrate the fact that the dynamite could be projected in shells from an 8-inch rifle gun with a 40-pound charge of powder. The great chemist, Nobel, never, perhaps, thought of applying his invention to this delicate test; but his powerful and wonderful gelatine, made only to be detonated in mines and the like, stood in several instances the tremendous initial shock of the gunpowder, and, by the aid of the rectangular diaphragms devised by Captain Whipple, of the Ordnance Department, stood, what is thought to be equally dangerous, the heat developed by the angular velocity. If the gelatine had been especially undertaken by these chemists for a military and not an industrial agent, and enough time and means had been at hand to perfect the diaphragm, it is believed all of the shells would then have become, as they will be in future, high-explosive batteries, projected with as much safety as though they had been charged with black gunpowder."

Major McKee, in reviewing various experiments that have been conducted under the direction of the Ordnance Department, speaks

of them as follows. Of the method exhibited by Mr. Snyder* he says: "He did fairly well with some of his firing at the Hook and on the Potomac, near Washington, D. C., and, as he is a man of inventive talent and an American, no one wishes him more success in his future experiments with dynamite than the men who were delegated by the Government to supervise and report upon those he originally undertook." In the experiments with shells loaded with dynamite, conducted by Brevet Brigadier-General John C. Kelton, at Point Lobos, near San Francisco, Cal., in March, 1885, no specially camphorated or otherwise prepared explosive was used, but the shells were charged with the crude blasting industrial dynamite. Three rounds were fired from a 3-inch wrought-iron rifled gun, shells with 200 grams of dynamite, and a variable charge of projection. The target was a large rock at 157 yards distance. In the first two rounds the shell burst into innumerable pieces on striking the rock, but in the third it burst within the piece. Colonel Kelton considered this experiment as very satisfactory, since it demonstrated the possibility of employing dynamite in shells, as well as the great strength of this great explosive; and he estimates that for the effective use of the artifices, which, according to him, is to destroy ships, one half the length of the projectile is the penetration needed, requiring 0.001 of a second, and he expects it will be successful.

After describing some experiments at Sandy Hook in 1883, Major McKee sums up the results as follows:

"As detailed in the records, three shells were fired with fulminate of mercury fuzes. The fulminate was too sensitive to stand the shock, and it was found afterwards that the gelatine needed no detonator.

"Although the tests made were very few, it would nevertheless appear from them—

"1. That the shells explode after clearing the muzzle, and therefore the detonation of the gelatine is due to some cause other than the shock of discharge—very possibly the heat generated by angular velocity.

"2. This is corroborated by the fact that one shell passed through a 2-inch board target without explosion.

"3. The gelatine used in these tests not being camphorated renders it highly probable that a certain percentage of camphor added would

* Proc. Nav. Inst. 12, 617; 1886, and 13, 411; 1887.

establish a compound which could be fired successfully in a specially constructed shell.

"4. The gelatine does not require a fuze or detonator of any kind.

"5. It is believed the shell which destroyed the 3.2-inch breech-loading gun broke from the shock of discharge, or admission of powder gas, and thus detonated the gelatine."

In the summer of 1884 the Ordnance Board fired four cast-iron screw shells from an 8-inch muzzle-loading rifle, using 40 pounds of powder in the gun, and from 5 to 8 pounds of gelatine in the shells at each discharge. The gun was mounted on a cradle and directed at a target 383 feet distant. One of the shells burst at or near the muzzle with little comparative violence. The other three reached the target, penetrated about seven inches, and detonated from the shock. These trials led to the making of six steel shells, three of them being cast and three forged. Analysis of the facts connected with these experiments shows—

"1. That the 3-inch shells designed for gunpowder charge, when loaded with Hill's explosive gelatine three months old, all cleared the gun without injuring it in the slightest.

"2. That the shells, having to be charged through the fuze holes with the dynamite, were necessarily packed loosely, thus subjecting the charge to the powerful action of angular velocity.

"3. That in the trials made with the 3.2-inch, two Butler shells charged with black gunpowder broke up 'at or near the muzzle'; while of the two Butler shells charged with Nobel's gelatine, or dynamite, one broke up 'at or near the muzzle,' and the other reached the target and exploded on impact.

"4. That in the trials made with the same 3.2-inch gun, using thin Hotchkiss shrapnel cases, charged with Nobel's dynamite, or gelatine, all cleared the gun in safety (one reaching the target after passing through two-inch boards) with the exception of one, which the Board reported on as follows: 'It either broke from the shock of discharge or admitted powder gas.'

"5. That all the trials with the 8-inch shells charged with fresh Nobel's dynamite, or gelatine, were successful, three of the shells detonating at the target, and one only exploding at or near the muzzle; that the gelatine used when the premature explosion took place was sixteen months on hand in this country after crossing the ocean, and therefore not such as was recommended by General Abbot, or contemplated by the Board."

Major McKee's conclusions are as follows: that the United States officers undertaking the investigation of this subject were necessarily compelled to institute their inquiries *de novo*. All foreign information was so meagre, so unsatisfactory, and so shrouded in mystery, in accordance, doubtless, with the policy of the European governments, that it was seen, after careful investigation, that all trustworthy knowledge would have to be gleaned by Americans through experience. In obtaining this experience, devices have been experimented with, invented by Mr. Snyder, who presented several plans; Mr. C. P. Winslow, with a nitro-glycerine shell, in which the glycerine and combined nitric and sulphuric acids are placed in separate glass vessels within the shells; Mr. Garrick, with a mortar and projectile for nitro-glycerine; Mr. D. P. Hill, with an 8-inch explosive gelatine shell; Mr. Stevens, with a double shell for high explosives; Mr. Graydon, with a shell containing the dynamite in capsules; Mr. Taylor, who brought his own gun and attempted to use dynamite as a propulsive charge; and Mr. Smolianoff, experiments with whose gun were made as late as last October.

In all these trials, Major McKee said, as to the practicability of using dynamite as a shell explosive, that it was well understood by the officers undertaking them that the crude blasting compound of industry, which was the only available explosive attainable, was not the eventual product of chemistry which would satisfactorily answer this purpose. It was known that great improvements had been made in the dynamites of all kinds, especially in the blasting dynamite or gelatine of Nobel, and that these compounds presented in transportation by all modern conveyances, and in all mining and other industrial works, as much, if not greater, safety than the black war, sporting, and the blasting gunpowders of commerce. With this status of dynamite apparent, it was seen that the time had arrived for military men in the United States to begin with it as a shell explosive, with some possibility of success. When it was demonstrated that the freshly prepared crude commercial dynamite might be fired in a shell from an 8-inch gun with a charge of forty pounds of black gunpowder, the only question that then remained was as to the stability and reliability of the compound through age. And when, after sixteen months' storage, it appeared to be more sensitive to shock, the Ordnance Board recommended that no more experiments be made with it until it was further camphorated, or otherwise treated by competent chemists. And it was ascertained further, in these few and inexpen-

sive tests, that the heat developed by the angular velocity was a more potent factor in detonating the dynamite than was the shock of discharge. It has been seen, also, that, since the comparatively recent discovery of nitro-glycerine, its development has been rapid in the protean forms of dynamite. In Europe experiments are being constantly conducted to perfect this agent, and doubtless they will succeed. Even now they claim in France and Germany to have perfected melinite and helphonite (?), compounds probably of nitro-glycerine and some of the ethers (sic). In Russia they also announce some new improvements that are not known here. But in the near future there is every probability that the problem will be solved in this country.—*Science* **11**, 153, 154; March 30, 1888.

The surgeons who examined the bodies of the soldiers killed by the explosion of melinite at Belfort,* report to the French Chirurgical Society that of the seventeen men hit only six lived. The bodies of the slain, it is said, were literally torn into shreds, and it is the belief of Dr. Tachard and his assistants that much of the substance exploded only after entering the bodies, or, in other words, that melinite as now compounded explodes at different periods, some early, some late; the first bursting the shell into fragments, and the latter adhering to these fragments, exploding when driven home. They remarked on the absence of burns and of poisoning. The bodies of the wounded were found to be tatooed as if with explosive dust.—*Army and Navy Jour.* **25**, 621; Feb. 25, 1888.

On November 3, 1887, Dr. S. H. Emmens made some public experiments at his home on Prospect Avenue and One Hundred and Sixty-fifth Street, N. Y., to demonstrate the qualities of his new explosive, "Emmensite." "The explosive is composed of two cheap and easily obtained materials; one is an extract from coal, and the other a mineral substance. The mixture may be pounded in a mortar, and neither ingredient separately shows any trace of an explosive nature. Another valuable quality which is claimed for emmensite is that it may be melted and fused into any shape, as a solid block, or may be granulated in various sizes; consequently, it may be used either as a high or low explosive. According to Dr. Emmens' computation, it can exert a pressure of 283 tons to the square inch, the next highest pressure being exerted by pure nitro-glycerine, 264 tons. The speed

* Proc. Nav. Inst. 13, 581; 1887.

of explosion is greater than that of any other practicable explosive, except fulminate of mercury. When used in a compact form, its highest possibilities of speed are obtained, and it is then suitable as a blasting agent. When manufactured in the form of powder, the rapidity of explosion is lessened in proportion to the coarseness of the grains, and it may then be employed in firearms. To-day a 32 caliber Smith & Wesson was fired from a distance of 6 feet at an iron plate $\frac{1}{16}$ of an inch thick. With four grains of emmensite the ball nearly pierced the plate, while with ten grains of powder the ball made only an indentation. A leaden hemisphere was placed on a rock; upon this were placed, successively, one ounce cartridges of gunpowder, explosive gelatine, dynamite, and emmensite. While the other explosives bent the lead, it was shattered by the emmensite. An iron plate 6 inches square was then suspended from the branch of a tree. A one-ounce dynamite cartridge placed on the plate simply bent it; a cartridge of explosive gelatine almost broke it; while the same amount of emmensite made a hole through the plate as large as a man's fist. Then, to show that the explosive would strike upward as well as downward, a cartridge was suspended and a leaden hemisphere was placed over it. After the explosion the lead was found to be not only shattered on the under side, but on its upper side also. The explanation is that the explosion took place with such rapidity as to force the gases through the pores of the lead, a thing which happens when the outer plates of a piece of artillery are injured and the inner plates remain unaffected by the shock. A piece of emmensite was immersed in a barrel of water for 1½ minutes and then exploded easily. Experiments were also given showing the value of the invention for pyrotechnical purposes. In its ordinary state, emmensite is a yellow powder and is a powerful dye, and the hair and beard of those handling it have become of a brilliant blood red."—*Boston Herald*, Nov. 4, 1887.

At the session of the French Academy of Sciences for December 12, 1887, Professor Berthelot presented a paper on the "Different Modes of Explosive Decomposition of Picric Acid and the Nitro-Compounds." After noticing the general belief which has existed regarding the explosiveness of picric acid, and alluding to Colonel Majendie's report* on the recent accidental explosion in England, he described the following experiments. When a notable quantity of

* Proc. Nav. Inst. 14, 149; 1888.

picric acid is heated in an open flask or capsule, it first melts and then volatilizes, giving out fumes which burn with a smoky flame, but no explosion takes place. When, however, a test tube about 25 to 30 millimeters in diameter is heated over a gas jet so as to produce a visible red, but without melting the glass or deforming the tube, on dropping into it some few milligrams of the acid, in crystals, a sharp detonation occurs, attended with a bright white light and the characteristic noise. When the experiment is performed in nitrogen gas, a few flakes of carbon are deposited; in ordinary air the result is the same, but no carbon is left. On increasing the quantity of picric acid, without, however, exceeding a few centigrams, the addition may cool the bottom of the tube sufficiently to prevent immediate detonation, but the substance is at once volatilized, and an explosion, attended with flame occupying a great part of the tube, occurs. This explosion is not so sharp as the more local detonation, and more carbon is apparently deposited. An explosion of this nature may be produced with a few milligrams of material, by using a glass tube coated with the carbon of a previous explosion. With a decigram of the acid and a fresh tube, the reaction will be slower still, yet a series of deflagrations with red flame will be observed, while the vapor will catch fire at the mouth of the tube. Finally, with large quantities the acid is decomposed, there being abundant fumes and partial volatilization without deflagration. Other nitrogenized bodies, less rich in oxygen than picric acid, such as the mono- and dinitrobenzenes and the nitro-naphthalenes, were experimented with and afforded similar results, thus leading to the conclusion that the mode of decomposition of all these nitro-substitution compounds depends on the initial temperature of decomposition.

Respecting picric acid more especially, M. Berthelot's conclusions are as follows: Should a nitro-compound, such as picric acid, while burning in large masses, happen to heat the sides of the containing enclosure to a degree sufficient to induce incipient deflagration, the deflagration might contribute to further increase the temperature of the enclosure, and the phenomenon might occasionally be transformed into a detonation. It would even suffice that the detonation should occur in an isolated point, either during a fire or owing to the local overheating of a boiler or apparatus, to enable it to originate the explosive wave and propagate itself by influence throughout the whole mass, causing a general explosion.—*Comptes Rendus* **105**, 1159–1162; Dec. 12, 1887.

Picric acid, picrates, and mixtures of picric acid with certain other substances, being "under certain conditions specially dangerous to life and property by reason of their explosive properties," an Order in Council has been issued in Great Britain under the provisions of the Explosives Act, 1875, declaring:

"(1) Picric acid when in process of manufacture or storage shall (for whatever purpose used or manufactured) be deemed to be an explosive within the meaning of the said Act for all the purposes of the said Act, subject to the exceptions following: (*a*) Picric acid when wholly in solution shall be exempt from being deemed to be an explosive within the said Act; and (*b*) picric acid which does not fall within the exemption above set forth, but which is being manufactured or stored in a factory, building, or place exclusively appropriated to the manufacture or storage of picric acid, and in such manner as effectually to prevent any picric acid from coming into contact (whether under the action of fire or otherwise) with any basic metallic oxide or oxidizing agent, or other substance capable of forming with picric acid an explosive mixture or explosive compound, or with any detonator or other article capable of exploding picric acid, or with any fire or light capable of igniting picric acid, shall be exempt from being deemed to be an explosive within the said Act. (2) Picrates and mixtures of picric acid with any basic metallic oxide, or any oxidizing agent, or with any other substance capable of forming with picric acid an explosive mixture, or any explosive compound (for whatever purpose used or manufactured), shall be deemed to be an explosive within the meaning of the said Act for all the purposes of the said Act, unless such picrates or mixtures be wholly in solution." —*Jour. Soc. Chem. Ind.* **7**, 48; Jan. 31, 1888.

Fleck states in the *Chem. Centr.* p. 99, 1887, that if a solution of picric acid is evaporated in a porcelain dish, the residue then being moistened with a 10 per cent solution of hydrochloric acid, a small piece of pure zinc being added to this and the whole allowed to remain in the cold for some hours, a fine blue color is developed. A solution of dinitrocresol (Victoria Yellow) treated in the same way yields a bright blood-red color. The original solutions are best made by extracting with alcohol.—*Jour. of Anal. Chem.* **2**, 120; 1888.

In a lecture delivered before the Aldershot Military Society, February 2, 1888, by Sir Henry Halford, on the new magazine gun

recommended for adoption by the British service, he says of the explosive to be used: "We take Curtis and Harvey No. 6 for instance, but that requires a great deal of room, and the Swiss have managed to compress their powder in such a way that they can put 70 grains into the space occupied by 55 of our powder. It is quite true that powders for small arms are in their infancy. We hear of nitrate powder, smokeless powder which will be suitable and accurate for rifles. . So far I believe it has not been used with success. The French find it will not keep. For use it is impossible to take a powder that will not keep for at least ten years. If we adopt a powder without adequate time being taken to test its storage capabilities, it will be a bad thing for the country. But we can take Rubini powder and work with that, and meanwhile make experiments with these nitrate powders and see if anything can be done towards getting a smokeless powder for the future."—*Army and Navy Jour.* **25**, 601; Feb. 25, 1888.

Prof. W. Mattieu Williams infers, from an examination of Count Rumford's "Essay on Gunpowder," that he produced solid carbonic acid* in the course of his experiments on the explosive force of that composition. In an experiment with a confined cylinder the Count observed "an extremely white powder, resembling very light white ashes, but which almost instantaneously changed to the most perfect black color upon being exposed to the air." Prof. Williams supposes that this white evanescent ash-like deposit was solid carbonic acid. The change to black mentioned by Rumford was caused by the instantaneous evaporation of the acid which revealed the ordinary black deposit of gunpowder beneath it. The pressure under which the experiment was conducted was 9431 atmospheres, which is abundantly sufficient to effect the solidification of carbonic acid.—*Pop. Sci. Month.* **29**, 718; 1886.

The Royal Prussian Fire-Damp Commission has carried out a series of experiments in the Royal coal-mine near Neunkirchen, the results of which go far to confirm Mr. W. Galloway's† theory of the agency of coal-dust alone, and in conjunction with fire-damp, in propagating explosions in mines. At the mine in question is a blower for fire-damp at a depth of 131 yards below the surface, which gives off 0.9 cubic feet of gas per minute. For the experiments cannon were planted at the closed end of a horizontal gallery 167 feet long, having

*Proc. Nav. Inst. 12, 621–623; 1886. †Ibid. 12, 429; 1886.

a branch 33 feet long, starting at a distance of 93 feet from its closed end. The branch gallery was closed at both ends with two-inch planking. One gun was fired when the gallery was free from fire-damp and from coal-dust; the flame of the shot was a little over 13 feet long. In a second experiment the floor of the gallery was strewed with coal-dust 1.17 inches thick for a length of 65 feet. The shot gave rise to a loud detonation, and the resulting flame filled the gallery to a distance of 88½ feet. The inner planking of the branch gallery was broken. In the third experiment the gallery floor was strewed with coal-dust for a length of 130 feet. The flame traversed the whole length of the gallery with great velocity, and came out at the open end to a distance of 16 feet, or 183 feet in all. It also emerged from the branch gallery to a distance of several yards. The outer partition of this gallery was broken into small fragments. For the fourth experiment, the partitions in the branch gallery were replaced, coal-dust was strewed on the floor for a distance of 65 feet, and a volume of 35¼ cubic feet of fire-damp was introduced and completely diffused. The firing of the shot produced a flame 190 feet long, accompanied by a report like a thunder-clap. The inner brettice of the branch gallery was broken and drawn several yards into the main gallery, but the outer one remained intact. The incidental effects of the last two shots also indicated how tremendous a force had been let loose when coal-dust formed one of the elements of the explosion. These experiments were typical of two hundred similar ones that had been made with from one to seven guns, all marked by results sustaining the coal-dust theory.—*Pop. Sci. Month.* **27**, 714; 1885.

We are indebted to Sir Frederick Abel for a copy of his very valuable paper on "Accidents in Mines," which is reprinted, together with the discussion, as a pamphlet of some 200 pages, from the *Proc. Inst. Civ. Eng.* for 1886–1888, and from which we propose to abstract for a later number of these Notes.

A striking new experiment, exhibiting the explosive nature of "Nitrogen Chloride," is described by Prof. Victor Meyer in the *Ber. Chem. Gesell.* **21**, 26–28; 1888. A few drops of yellow chloride were prepared in the usual manner by inverting an exceptionally thin flask filled with chlorine gas in a leaden dish containing a solution of ammonium chloride. Instead, however, of gently agitating the apparatus so as to cause the drops to fall into a smaller leaden capsule placed beneath the mouth of the flask, they were allowed to float freely

upon the surface. The whole apparatus was then enclosed in a cover-box fitted with stout plate-glass sides, through the top of which was passed a bent pipette, turning up below just under the mouth of the flask, and connected outside with a dropping funnel containing ammonium chloride solution and a few drops of turpentine. When sufficient nitrogen chloride had collected, the tap of the funnel was carefully turned so as to allow a little turpentine to slowly rise in the flask. After a moment or two it reached the surface and mingled with the nitrogen chloride, causing a brilliant flash of light and a loud explosion, which Prof. Meyer likens to a thunder-clap, so much more powerful is the detonation in a confined space. The flask, of course, was shattered, not into powder, but into tolerably large fragments; the plate-glass box, however, even after many repetitions of the experiment, remained intact, a small door on the side away from the observers having been left ajar so as to prevent any notable increase of pressure. Curiously, the nitrogen chloride never entirely exploded; a part remained in the distorted leaden dish and maintained an incessant fusilade for more than a minute.

At the last meeting of the Göttingen Chemical Society, Dr. Gattermann read a preliminary note upon his recent researches on "Nitrogen Chloride." From his analyses it appears pretty clear that the yellow liquid is a mixture of at least two distinct chlorides, which he has hopes of being able to separate. During the course of his experiments the reason of its capricious behavior, which has been the cause of so many painful accidents in the past, was happily discovered. It is decomposed by the actinic rays of light, being rapidly acted upon by sunlight with periodic spontaneous explosions, and being at once fired by exposure to the rays of burning magnesium. Hence the further study of this subject must be carried on in the dark room.—*Nature* **37**, 350; Feb. 9, 1888.

These results of Gattermann's with nitrogen chloride recall those obtained by Guyard with nitrogen iodide, *Bull. Soc. Chim.* **41**, [2] 12; Jan. 1884. He found the action of light on this amide so marked that he proposed to use the phenomenon for photometric purposes.

Through the courtesy of Dr. Wolcott Gibbs we learn that in 1843 or 1844, while Dr. John Torrey was exhibiting to his class at the College of Physicians and Surgeons of New York the oxidizing effect of fuming nitric acid on phosphorus, a tremendous explosion ensued. The experiment was made by placing the fuming nitric acid in a

stout platinum crucible which rested on a stone slab, and dropping in the piece of ordinary phosphorus from the end of a rod which held it. The explosion followed immediately on the phosphorus coming in contact with the acid. A curious result of the explosion was, that while the sides of the platinum crucible were extended, the bottom was driven upward, so that the vertical cross-section was changed from the shape of a U to nearly that of a W.

In discussing the "Origin and Structure of Meteorites," *Pop. Sci. Month.* **29**, 374–386; 1886, M. A. Daubrée says nothing in the exterior form of meteorites is more striking than a general aspect indicating that they are parts of a broken body. When we compare hundreds or thousands of stones of the same fall, we find that they all present polyhedral forms, like those of stones broken for a macadamized road, except that the angles are more or less rounded. Even meteoric iron exhibits this angular shape, showing that its malleability and extreme tenacity have not preserved it from a violent rupture. It seemed impossible that such effects could be produced solely by the action of the air, especially in the upper regions where it is in an extremely rarefied condition. But light has been thrown upon the problem since the introduction of the new explosives, which illustrate, in their industrial applications, the prodigious force that gases are capable of exerting, even in small quantity, when they are suddenly animated by a considerable tension. The explosion of a kilogram of dynamite will break up bars of steel which a pressure of a million kilograms would hardly crack. Similar conditions exist in the upper strata of the atmosphere, slight as their density may be, when a meteor moving with planetary velocity strikes upon them. The body compresses the air more rapidly than it can yield, and transmits an equivalent motion to its own molecules. Under these circumstances, in the successive detonations caused by an enforced rotation, iron and the most tenacious bodies will fly into pieces as if they were struck with a pile-driver.

There is another no less characteristic feature of the surface of meteorites which testifies to the violence of the mechanical action produced upon them by the atmospheric rebound, exhibited by rounded cavities resembling finger-marks. They appear in the stony meteors, but are particularly characteristic of the iron masses. These marks were at one time attributed to transient explosions taking place during the course of the meteor through the air; but experiment has shown that the same appearance is produced in

bodies which are acted upon by an explosion of dynamite, in the grains of coarse powder that drop, half consumed, from the mouth of a cannon when it is fired, and upon the touch-hole of the cannon. They are all due to the same cause—to the erosive action of gas revolving rapidly and moving spirally and under high pressure against the projectiles, boring into them as if it were a gimlet. The mechanical action is accompanied and aided by a chemical action which is dependent upon the combustible nature of iron at high temperatures. Although these blister-holes are worked only on the face which is exposed to the direct pressure of the gas, meteorites present them on various sides, and sometimes over their whole surface. This arises from the rotatory character of the motion of the body, which makes it present every side in succession to the front.—(*From Revue des Deux Mondes.*)

Dr. H. G. Piffard proposes the use of a mixture of gun-cotton and powdered magnesium for the production of a light by which instantaneous photographs may be made at night. The burning magnesium furnishes a light which is rich in actinic rays, and the burning gun-cotton supplies the heat necessary to cause the instantaneous combustion of the magnesium. The mixture has been flashed from a pistol.—*Newport News*, Oct. 31, 1887.

According to the *Sci. Am. Sup.* **25**, 10230; April 7, 1888, a new use for soluble gun-cotton has been found in the manufacture of a fibre called "Artificial Silk." This fibre is prepared by De Chardonne by dissolving 3 grams nitro-cellulose in 100 to 150 cc. of a mixture of equal parts of alcohol and ether. 2.5 cc. of a filtered 10 per cent solution of ferrous chloride in alcohol, or of stannous chloride, and 1.5 cc. of a solution of tannic acid in alcohol are then added. The filtered liquid is placed in a vertical reservoir having at its bottom a blow-pipe nozzle of glass or platinum. This pipe forms an acute cone with an orifice of from 0.10 to 0.20 mm., the thickness of the margin not exceeding 0.1 mm., and opening into a vessel of water acidulated with one-half per cent. of monohydrated nitric acid. The level in the reservoir being some centimeters higher than in the vessel of water, the overflow proceeds easily. The fluid hardens at once in the acidulated water, and may be drawn out by a uniform movement in the form of a thread which must be dried rapidly by traversing a current of dry (not hot) air, and may be wound up as

soon as dry. Soluble coloring matters may be introduced into the solution so as to obtain threads of all colors.

The *Journal du Matelot* of Jan. 14, 1888, contains an account of an invention of M. W. Meissel's, of the North German Lloyd line, for throwing oil from a ship upon the billows which endanger her safety. This consists in attaching thin zinc cylinders, filled with oil, to the end of a rocket, so arranged that the explosion of the rocket shall rupture the cylinder and distribute the oil. Experiments were made from the Vesra in the middle Atlantic and they gave excellent results, and proved that they could be fired directly ahead either in the air or under water.

The *San Jose* (*Cal.*) *Mercury* of January 22, 1888, cites the results of several experiments with this rocket. In one experiment the rocket was thrown to a distance of 1000 feet. By the explosion of five rockets at from 1200 to 1500 feet from the ship, a space of from 1500 to 2000 square feet of water was covered with oil and the waves were at once smoothed. The rocket was fired 900 feet against a gale. The value of the invention to deep-water sailors consists in the certainty of explosion of the rocket at sufficient distance to leave the vessel in calm water during a gale.

The *Newport News* of April 2, 1888, states that a patent has been granted Mr. Timothy Akin, Sen., of Gosnold, one of our branch pilots, for a rocket or projectile made of metal and filled with oil, which is to be thrown from the shore near or around vessels that are stranded. It can be thrown from the same gun that throws the life line across stranded vessels. The rocket sinks in the ocean and the oil that is contained therein escapes and floats on the surface, which makes the water comparatively smooth and stops the sea from breaking, thus enabling the life-saving crews to work in smooth water while they are engaged in their perilous duty going to and fro from the stranded vessel saving life. Capt. Akin has tried them and they work well. He intends to send them to the different life-saving stations so that they can be fairly tested and tried.

Mr. Wolcott C. Foster gives in the *Engineering News* **19**, 254; March 31, 1888, a "List of Explosives Containing Nitro-glycerine," in which the names of some forty different explosives, together with the different grades of each and their nitro-glycerine contents, are enumerated.

PROFESSIONAL NOTES.

STEEL: ITS PROPERTIES; ITS USES IN STRUCTURES AND HEAVY GUNS.

By Wm. Metcalf, Trans. Am. Soc. Civil Engineers.

A Review.

The year just passed has been a notable one in the history of gun-making in the United States, not only because of the actual work accomplished and the promise of more to be accomplished in the immediate future, but almost equally because of the widespread interest aroused in the subject outside of military circles.

This interest has been evinced by the appearance of no fewer than six papers from prominent civil and mechanical engineers, four of which have been exhaustively discussed by officers of the army and navy and by many of the leading engineers, metallurgists, and inventors of the country.

The first impetus was given to the discussion by Mr. Dorsey's paper before the Naval Institute on Steel for Heavy Guns. This was followed in the Proceedings of the Institute by Mr. Wm. J. McAlpine's paper on the same subject, by Mr. W. F. Durfee's on Iron and Steel and the Mitis Process, and by Mr. A. H. Cowles on Aluminum Bronze. In March the subject was brought before the American Society of Civil Engineers by Mr. Wm. Metcalf. Finally, the last month of the year has brought a paper—just issued—on "Gun Making in the United States," from the pen of Captain Rogers Birnie, Jr., before the Military Service Institution at Governor's Island.

Every one of these papers should be read by all who wish to understand the metallurgy and manufacture of heavy guns. Taken together, they probably contain every argument which has been brought, or is likely soon to be brought, against the type of guns which has been adopted for the new armament of our ships and forts, together with the replies of ordnance officers and gun manufacturers to those arguments.

To us it seems that no impartial reader of these papers can fail to find in them abundant evidence of the wisdom shown in the selection of this type, or fail to be gratified at the way in which all arguments against it have been met and answered.

With the papers of Mr. Dorsey, Mr. McAlpine, Mr. Durfee, and Mr. Cowles, the members of the Institute are already familiar. It is proposed here to give them some information as to Mr. Metcalf's paper before the Society of Civil Engineers and the discussion which followed it.

The paper is in two parts, of which the first is devoted to a consideration of the nature, peculiarities, and treatment of steel, and the second to the use of steel for guns.

Toward the close of the discussion Mr. Metcalf expresses regret that the first part of his paper should have been overshadowed in the importance given to the second part by those who joined in the discussion; but this would seem to have been due not to any lack of interest in the views expressed upon the nature and treatment of steel, but to the almost universal consent with which those views were received.

However this may be, we of the Navy have much reason to congratulate ourselves upon the result, which is, that the discussion turned almost entirely upon that part of the paper relating to guns.

It is of course with this part of the paper that we shall principally deal, though nothing that Mr. Metcalf has to say of steel could fail to be of interest and value. His principal points, until he comes to gun-making, are summarized at the end of his paper and may well be given here in his own words.

"Iron and all metals are liquids.

"Cold steel is congealed iron, containing in solution various ingredients which give to it certain marked properties.

"Heat is the power which gives to steel all of its good and all of its bad conditions.

"Steel changes in volume and structure with every degree of heat that is applied to it, and the changes may be read in the fracture as surely as we read the changes in volume in the mercury column.

"Slow, quiet cooling from a high temperature causes the formation of large, irregular crystals and renders the steel weak.

"Quick cooling and agitation form small, uniform crystals and a strong condition.

"The application of heat alone will change the form and the size of the crystals.

"The change of volume due to a unit of heat increases as the content of carbon increases; therefore high carbon steel must be handled with exceeding care.

"The temperature to which it was last subjected, moderated by its subsequent treatment, is always recorded in the structure of steel, and may be read there if the piece be fractured.

"Annealing, making soft, ductile, and uniform in texture is the most important of all operations, from an engineer's point of view.

"Although annealing will relieve strains and change a coarse structure to a fine uniform grain, it must not be supposed for a moment that any amount of annealing will heal a rupture. I do not believe there is any cure for a rupture, because I do not believe steel can be welded.

"Steel being crystalline, has no fibre; therefore there should be no sharp angles, no sharp edges, and no unfilleted corners; the surfaces should be smooth and free from tool marks or indentations caused by sledge blows and the like.

"With our present knowledge, the best steel for structural purposes is that which is most nearly composed of iron and carbon.

"Finally, good steel, properly worked, is the most useful of all of man's productions, and it may always be relied upon to do its full work to its utmost limit; but if the laws of its being be violated it will as certainly respond, causing disappointment and disaster."

Great value is attached to annealing—the process, it will be remembered, upon which the advocates of our present system of gun-making have laid special stress, but the usefulness of which has been called in question by Mr. Dorsey and others. Upon this subject Mr. Metcalf's words should be conclusive. He says:

"It is a remarkable, and probably the most important property of steel, that no matter what the grain may be, no matter how coarse from overheating, or how irregular from uneven heating, if it be heated uniformly to the refining heat and kept at that heat long enough, the crystals will change in size and will all become small and uniform, so that the fracture will be so even that it will be called fine-grained and amorphous. . . . .

"If an ingot be annealed properly it will lose every vestige of its distinctive crystallization; it will become refined and tough."

Now as to guns.

Mr. Metcalf, it is well known, advocates a gun of steel cast on the principle

which Rodman applied with so much success to cast iron smoothbores. The built-up gun he condemns as unscientific and unmechanical, holding that the conditions sought in building up can never be practically attained by that system, but that they may be attained by the Rodman process of casting hollow and cooling from the inside. In his paper he proposes to apply this principle as it was applied by Rodman, casting the gun with a hollow core through which water circulates, at the same time keeping up the temperature of the outside by the application of heat in the pit. The object of this process is to place the successive layers of metal from the bore outward in a state of varying tension; that is to say, to set up internal strains. The gun is then to be annealed. But the object and effect of annealing, as Mr. Metcalf very clearly explains, are to *remove* all internal strains and to place the metal throughout the mass in a state of rest; that is to say, having gone to great trouble and expense to produce internal strains, he goes to still further trouble and expense to remove them. This inconsistency having been pointed out by Lieutenant Ingersoll and Lieutenant-Commander Barber, Mr. Metcalf shifts his ground somewhat and says that he thinks it would be more convenient to cast the gun solid, bore it out, and then proceed with the treatment. He says nothing, however, of any change in the order of treatment, and as his change of plan is based wholly upon convenience and not upon principle, it seems reasonable to understand that the order of treatment is to remain the same. In the Rodman process the tensions are set up in cooling the metal from a state of fusion. Annealing must of necessity follow this. If the gun is cast solid, bored out, and then subjected to the same treatment, it will be heated to a high temperature, cooled from the inside, and afterward annealed. This is still setting up internal strains by one process and removing them by another, so that the point made by Lieutenant Ingersoll and Lieutenant-Commander Barber is not met by this change of ground.

Later in the discussion the same point having been made by Mr. Marshall, Mr. Metcalf says, "Slow reheating to the right temperature will insure the formation of uniformly minute crystals and great strength, and, having secured these conditions, cooling from the interior, whether rapid or not, will secure initial tensions in the directions desired."

We are now surely far enough from the Rodman process of manufacture. The principle, it is true, is retained; the principle, that is, of varying tensions; but so is this principle maintained in the built-up gun. It is the very essence of the built-up system. The point at issue between Mr. Metcalf and the advocates of built-up guns is one, then, upon which neither side can justly appeal, as against the other, to the "spirit of Rodman." Both parties accept Rodman's principle, but both propose to modify his method, for the very excellent reason that they are dealing with a metal to which his method does not apply. There is no reason to assume that if Rodman were living to-day and engaged in the manufacture of steel guns, he would of necessity cling to the methods which he invented forty years ago for cast iron. He was, before all things, a progressive man, always in advance of his age, never lagging behind it. It may be remarked, however, that there seems a somewhat unjustifiable tendency in certain quarters just now to make a fetish of him. He was undoubtedly a remarkable man and a very able artillerist. He made guns which were perhaps the best of their day, but which were certainly not perfect guns. The opinion prevails very generally among the advocates of the cast steel gun that no Rodman guns ever failed. This is as far from the truth as the conviction held by the same people that a great many built-up steel guns have failed. The facts are all the other way. As noted by Lieutenant-Commander Barber, in the report of the Joint Committee on Ordnance, Senate, page 215, L. Congress, Third Session, there is a list of 249 cast-iron guns which have burst in the United States. Of these, 141 burst under fire, 10 burst spontaneously, and 98 cracked, fissured, or ruptured before proof. Of those which failed under fire, 24 were Rodman guns.

The Rodman process, then, did not make a reliable gun within its own proper limits of pressure, even of cast iron, the ideal metal for such a process; and the question naturally arises whether it can make a reliable gun for much heavier pressures, of steel, a metal many times more difficult than iron to cast. Assuming for the moment that the answer is in the affirmative; assuming that Mr. Metcalf can cast a gun solid, without blow-holes or other defects, bore it out, heat it uniformly throughout its huge and irregularly shaped mass to exactly the right temperature for annealing, maintain that even temperature for the proper time, and finally cool it from the inside, preserving such relations between the rate of cooling of the inside and outside of this irregular mass as shall insure the proper relations of tensions for the successive layers; assuming all this, will he in the end have a cheaper gun than can be made by manufacturing it in parts so small that each can easily be made perfect, treating each with reference to the strain it will have to stand in the finished gun, and then assembling these parts? Mr. Metcalf desires that his system should be considered chiefly with reference to very heavy guns, "from 100 to 150 tons." The casting (solid) for a gun to have a finished weight of 100 tons would weigh not far from 250 tons. This mass of metal having been cast with all the precautions necessary to secure uniformity, must be taken from the pit and put in the lathe to remove the sinking head and cut the bore. It must then be returned to the pit and there subjected to the treatment which is to give it its uniform granulation and its characteristic tensions, after which it must be again transferred from the pit to the lathe to be finished.

The mere handling of such a mass of metal must be a heavy item of expense, but a far heavier one will result from the proportion of failures which will be found an inevitable feature of the process.

Mr. Metcalf objects to the consideration of the castings that shall be lost in the pit "unless the makers of built-up guns will report every defective ingot as a failure of a gun." But the failure of an ingot for a built-up gun is not the failure of a gun. It is a failure and means the loss of only a small part of a gun, while the failure of a cast gun in the pit means the loss of the whole.

It must be agreed that cast iron is a far easier metal to deal with than cast steel, yet in a recent attempt at South Boston to cast the body of a 12-inch rifle (of cast iron), three failures were made before a successful result was produced. The weight of the finished piece required in this case was only 35 tons.

As to the expense of such disastrous failures, Mr. Wm. Sellers—a practical steel manufacturer of large experience—has said that if he were required to cast guns in one piece he would require a higher price than for a built-up gun, because of the proportion of castings which must be rejected. Mr. Metcalf himself sets the probable cost of the gun he proposes at from 20 to 30 cents per pound. But figures more precise than these have become available since Mr. Metcalf's paper was written. Bids have been received for the casting of a steel 6-inch gun in a single piece, the gun to be rough bored and turned only. The firms who bid on this did not propose to treat the gun by any such elaborate method as that of Rodman, still less by the modified method suggested by Mr. Metcalf. They proposed simply to cast the gun much as they would cast anything else, and then to bore it out and anneal it. Thus they were relieved from a very important part of the expense inseparable from Mr. Metcalf's method, and from all the expense of finishing, rifling, making and fitting the breech mechanism, etc.

Two bids were received for this very simple casting of 11,000 lbs. weight. They were: Pittsburg Steel Casting Company, $3300, or 30 cts. per pound; Standard Steel Casting Company, $5300, or 48 cts. per pound. The mean price then at which the manufacturers of this country are willing to furnish the rough castings for a gun in one piece is 39 cents per pound. If we add 10 cents for finishing, we have 49 cents per pound as the price of the gun.

Mr. Metcalf quotes figures from "Holley's Ordnance and Armor" to show that built-up guns cost from 70 to 80 cents per pound. Holley's figures are

just 23 years old, and are, as nearly as may be, just double the corresponding prices of to-day. The price of Whitworth steel built-up guns was quoted six years ago at 38 cents per pound. They are probably somewhat cheaper now. French steel guns cost about the same.

The Gun Foundry Board, whose careful and conscientious work has received universal commendation, estimated the cost of building guns in this country at between 37 and 38 cents per pound.

This estimate may be too low, and the estimate of 48 cents for the cast gun may be too high, but it seems certain, at least, that no such extreme difference of price exists in favor of the cast gun as would be inferred from Mr. Metcalf's figures.

The discussion of the paper was opened by Lieutenant Danenhower, who spoke very briefly. He said, "I should like to ask Mr. Metcalf what becomes of the compression of the Rodman gun after the gun is annealed." To this Mr. Metcalf replied, "What becomes of the hammering after the gun is annealed?" But the object of hammering and that of annealing are not opposed to each other. They both aim to produce uniformity and fineness of granulation, whereas the object of annealing and that of the Rodman process of cooling are directly opposed.

Mr. Metcalf continues: "In making a gun, if the first preparation by annealing does not give that condition of strength and fineness necessary, it is perfectly obvious to any one that a simple way to get it is to heat it to the proper point and bring every part of the steel to the best condition, then cool from the interior of the gun."

Commander H. B. Robeson, U. S. N., inquired as to the relative weights of built-up and of cast guns.

Mr. R. W. Hunt, M. A. Society C. E., while stating that he had had no experience in making guns, expressed a "strong hope that the theory of the steel cast gun will prove to be right."

Captain O. E. Michaelis endorsed the views of the lecturer and condemned the built-up gun.

Colonel W. C. Church said, "I am sufficiently well acquainted with Mr. Metcalf's views to be quite sure that I endorse what he has said."

Lieutenant W. H. Jaques, U. S. N., differed radically from the lecturer. As is well known, Mr. Jaques is a firm believer in the built-up gun. He calls attention to the magnificent endorsement of the building-up system involved in the willingness of a great commercial firm like the Bethlehem Iron Company to erect a plant for the manufacture of steel built-up guns, expressed long in advance of any guarantee that a single contract would be awarded them; and contrasts this with the position of the advocates of the steel cast gun, who, having the plant already on hand, await a positive order from the Government before committing themselves to the investment of the sum needed for the manufacture of the first gun on their system.

Dr. R. J. Gatling expressed the opinion that "steel for gun construction should be neither too hard nor too soft." He is a believer in cast guns.

Mr. F. Collingwood, M. A. Society C. E., thinks the cast gun is deserving of a trial, and that its rejection without trial can only be set down to the account of prejudice.

Mr. J. M. Knap, M. A. Society C. E., coincides with Mr. Metcalf in his view that the best heavy gun of the future will be that known as the steel cast gun. As regards smaller guns of 8-inch caliber or less, he says: "Such satisfactory results have been obtained both in Europe and in this country with built-up guns made of forged steel, that our Government should be encouraged in their efforts in this direction." He continues: "The essayist has given us the bright side of the Rodman cast iron gun. It has its dark side as well. I well remember, while associated with Mr. Metcalf in the manufacture of guns at Fort Pitt Foundry, our losing two or three 15-inch Rodman guns by their breaking in the mould."

Mr. A. H. Emery gives an unqualified endorsement of the built-up gun. Of the cast gun he says: "I think in regard to the low cost of the solid cast gun (I mean by that a steel gun cast in one piece and cooled from the interior), that we shall not find the cost low, but the quality may be. I do not expect to live until we can make a large mass of steel as good as the small masses have been made. As regards the cost I agree with Mr. Sellers, who says in regard to making guns in one piece, that if he were to do it he would require a greater price than for built-up guns. He would consider the difficulty of getting a gun of good quality so great, so many of them would be condemned, with the balance all uncertain, that he would greatly prefer to forge the gun in pieces and bore out and assemble them. As to what the gun of the future will be I may say briefly this—built-up gun of steel; and I would say that my experience as an engineer teaches me that the smaller the mass we finish the pieces of steel in, working it by the hammer or hydraulic forging, the better we shall find its quality: the smaller the mass the better we can inspect and know whether it is good."

Mr. John Coffin, A. M. Soc. C. E., contributes a long and very important paper upon steel, from which we have space to extract only his conclusion, which is to the effect that the steel cast gun has little prospect of success. He says: "The difficulties are great. A very large piece of varying section, uncertainty of maintaining desired temperatures throughout, a limited knowledge of the effect of these temperatures, and the great cost of all experimental work in this direction, lead me to believe that the day is very far distant for Pittsburgh's dream to be realized.

"I am a patriotic believer in American talent and enterprise, and if solid steel gun construction is ever successfully accomplished, I would like to have the honors here, but in our struggle to again gain the front let us not, like the crawfish, go backward."

Commander C. F. Goodrich, U. S. N., writes very briefly, expressing his confidence in the built-up gun, but adding, "The naval service is not, I trust, bigoted, and if Mr. Metcalf or any other person can give it weapons as efficient, as light, and as safe as those now coming into use, with the added merit of greater cheapness, I am sure they will be welcomed."

Lieutenant-Commander Barber quotes numerous authorities to show that while steel cast guns have long been advocated, no success has thus far been attained in their attempted manufacture. He refers especially to the experience of Terre Noire, "the most famous steel casting establishment in the world," where success has been attained in the casting of small gun hoops, but where, in spite of the large amounts of money expended and the practical encouragement given by the French Government, no further advance has been made, even to the larger parts of built-up guns. Several of Mr. Barber's other points have already been noted.

Lieutenant R. R. Ingersoll, after pointing out the inconsistency already referred to, of setting up initial strains by the Rodman method only to remove them by annealing, gives some figures as to the strength of a cast gun without initial tensions, and asks how the elastic strength of the cast guns would be computed. "The strength of guns should be a matter of computation just as surely and accurately as in the case of any other mechanical structure."

Mr. W. Sellers says: "In this discussion I propose to confine my remarks to the question of guns, for the reason that I find no other point in Mr. Metcalf's very able paper upon which to hinge a discussion; and even as to this, I am not prepared to say that the American gun of the future will not be a solid mass of cast steel, but only that I doubt it; because, although this may prove to be the cheapest way to make great guns in the future, it does not appear to be so now, and with the improvements in progress it is less likely to be so hereafter.

"If we could assume that every great casting for a gun would prove perfect, one very important element of cost would be eliminated; but if the present

high standard is to be maintained, it may be safely affirmed that a notable quantity of such castings will be condemned, and then what shall we do with them? We cannot permit such vast masses of material to cumber the ground, and it will cost far more than the material is worth to cut it into pieces small enough to remelt; and yet this is all that we can do, and the cost of doing it must be added to the cost of the good castings.

"The casting of an ingot heavy enough to make the tube of a sixteen-inch gun, boring it and forging it to the proper length, would be accompanied with far less risk than to cast the same weight in one piece of that length, with a core throughout cooled on the Rodman principle; and I believe that the cost need not be greater, while the quality of the material would be far more uniform in the forged piece, not solely because it was forged, but because the quality of the short ingot would be more uniform than that of the long casting. That the built-up gun is unmechanical, or that the quality of the material in such guns cannot be had in as perfect condition as in the solid casting, I do not believe."

Mr. Chas. A. Marshall, M. Am. Soc. C. E., contributes a long and very interesting paper, from which we can extract only a few salient points. He says:

"Disadvantages of casting the gun as a whole on the Rodman system are:

"First.—Enormously greater weight and size of casting: largely increasing risk of making. Cast iron is easier to handle than steel, yet the South Boston Foundry lost three castings before they succeeded with one.

"Second.—Very much slower cooling, which is the condition favoring un-uniformity by segration. The Rodman process doubtless seems to some minds a quick process of cooling, which is so, considering the size of the castings. Yet General Rodman states (Senate Rep. Com. 266, XL Congress, 3d Session, p. 80) that the time of cooling a 15-inch hollow cast gun was about six days, and that the outside temperature did not fall below 500 or 600 degrees temperature for about two days.

"Third.—As another consequence of the slow cooling, large, weak crystals.

"Fourth.—As another consequence of the slow cooling, a very low elastic limit to the outer metal certainly, and for the inner metal a higher value, but for the same kind of steel not anything to approach the treated gun tube quoted by Mr. Metcalf from Holley. The elastic limit to the outer metal would not be over 29,000 pounds per square inch for metal having same carbon contents as gun-hoop steel, which, it may be borne in mind, is the hardest steel used in the guns to-day—such metal as Cambria Iron Works are producing in hoops with an elastic limit of 55,000 pounds minimum by specification. . . .

"It may be profitable to enumerate in the most general way some of the advantages which the system of building up guns has over that of casting them whole: They are:

"With metal of equal strength, greater ductility. With metal of equal ductility, greater strength. Metal of more reliability, because (1) the blow-holes, if any, have been closed up or got rid of; (2) thorough tests can be made.

"Character of metal is known throughout. Character and amount of strains are known throughout and are controllable, so that two guns of same pattern are stressed the same. . . .

"The Rodman gun was an intelligent attempt to make a high power gun out of weak material; we have much superior guns to-day, though very few of them. If the hollow cast (or solid cast) steel gun has a field, it is as a low power gun for commerce-destroying or hasty inland defenses. In times of peace the policy of this nation being defensive, we do not want to invest money in commerce destroyers which would be useless in defending our ports, nor do we want to arm an expensive swift cruiser, even though unarmored, with inferior guns, albeit the cruiser would have to run away from an armored vessel. For coast defenses no guns but the best, because if ever used it will be against the best that the enemy has or can get."

Mr. Henry M. Howe thinks the difficulties to be met in making a steel cast

gun are less than those which Rodman met and overcame in applying his principle to cast iron. He says: "In view of the advantages of economy and of rapidity of production, I believe that the chances of producing by the Rodman plan a steel gun equal if not, indeed, superior to the best built-up gun, are sufficiently great to warrant the outlay required to settle the question by actual large scale tests."

Mr. Alfred E. Hunt, M. Am. Soc. C. E., in the course of an interesting paper which is largely devoted to other matters than gun manufacture, says, "I agree with Mr. Metcalf most cordially in his advocacy of the Rodman principle for the manufacture of steel guns."

Professor W. H. Burr, M. Am. Soc. C. E., says: "The experience of engineers with ordinary steel castings does not seem to me to justify confident expectations regarding the reliability of a gun produced by casting from steel with internal cooling. I am of course aware that the metal put into guns would not be precisely the same as that used for ordinary castings, but it is a very serious question in my mind whether such a mass of steel with no forging either in the liquid or solid state (for cooling is not forging) would be even approximately homogeneous.

"I do not assert it would not be, but in the absence of such a gratifying result as a large homogeneous steel casting free from gas fissures or bubbles, I do not believe that positive predictions on that side of the question can be at once accepted.

"In reasoning from cast iron guns to cast steel, it also seems to me that difficulties are not altogether avoided. In the first place, it is not an exaggeration to say that a gun of given caliber, in order to meet the requirements of modern ordnance, must do double the duty of the same gun under similar circumstances twenty-five years ago. Hence any fault in the material due to any part of the process of fabrication will result in far greater relative and absolute damage to the gun. If, therefore, the process of casting and cooling should prove to be more delicate and difficult to control with steel than with iron, as would probably be the case, the resulting product would be of most doubtful value.

"It seems to one not an expert in ordnance material that the first evidence of the fact that the requisite steel, with proper degree of homogeneity, high elastic limit and toughness, can be fabricated without forging either in the liquid or solid or semi-solid state, is yet to be produced.

"Hammer forging may be damaging to the material, but hydraulic forging is not, nor is forging in the liquid state, such as is obtained by the Whitworth process. It certainly is a fact that the best and most highly effective modern ordnance has been manufactured under processes involving those operations, with subsequent hardening and annealing. If the process of building up guns places the right kind of metal in such position and condition as to best resist the high intensities caused by firing, it certainly cannot be called unscientific. But if better results can be obtained at less cost by casting and internal cooling, by all means let us have them. Thus far, however, we have them on paper only, and that step is not a long one."

Mr. L. L. Buck, M. Am. Soc. C. E., says: "The practicability of making a steel cast gun successfully must depend upon whether a steel cast gun of such massiveness as is required for a large gun can be produced sound and strong enough to give it the required strength per square inch of section. If so, there appears to be no insurmountable obstacle to produce a successful gun in the manner proposed by Mr. Metcalf, as, without doubt, the other requisite conditions could be acquired as well with the steel castings as with iron castings. The unit strength of the metal could be considerably less in the cast than in the forged gun and yet make a stronger gun."

Mr. Gustave Lindenthal, M. Am. Soc. C. E., suggests that possibly the Mitis process would afford a solution of the difficulties involved in gun manufacture. "Supposing a tube of fine hard steel (to resist the abrasion from the shot or

projectile) as a core, around which were cast by the Mitis process the body of the gun of wrought iron; it would melt the outside of the hard steel tube, become thoroughly welded to it and form one whole piece. The ferro-aluminium used in the Mitis process as an addition to wrought iron is claimed to also prevent the crystallization of the cooling metal, which in addition has greater strength than wrought iron alone. It seems to me in that direction there is yet a field for great developments."

Mr. Theodore Cooper, M. Am. Soc. C. E., says: "I believe a steel cast gun can be made which can compete successfully with any form of built-up guns; but I fully realize that there is a costly experimental stage before success is reached. Having faith in our ability to improve upon the best European practice, I would like to see our manufacturers given a fair chance. They should not be expected to enter upon the expense and study without a proper reward in expectation." A. M. K.

A METHOD OF FINDING THE ELASTIC STRENGTH OF A METAL WITH THE RIEHLÉ HYDRAULIC TESTING MACHINE.

By Ensign J. H. GLENNON, U. S. N.

The method used with the Rodman testing machine, of finding the elastic strength of a metal, being impracticable with the Riehlé machine, owing to the slip of the liquid in the hydraulic cylinder past the piston, the following method, which requires no linear measurements, may be employed. Use is made of the fact that within the elastic limit a metal specimen stretches proportionally to the pull upon its ends. The method is best illustrated by a case in which it was successfully tried.

A steel specimen of the ordinary length, diameter .5 inch (area of cross-section .2 square inch), was placed in the machine. A load of 3000 pounds, equivalent to a tension of 15,000 pounds per square inch, was then applied by means of the crank, which was then stopped in order that the ordinary measurements of the specimen might be made. As might have been expected in a Riehlé machine, the weight scale settled down. After measuring the specimen the crank was turned until the scale again lifted at 3000 pounds, when the machine was stopped and a chalk mark placed on the top of the belt-wheel, the scale weight at the same time being moved to 4000 pounds. The crank was then turned as uniformly as possible until the scale lifted, the number of turns and fractions of a turn being counted. The crank was then stopped and measurements made, during which the scale settled down as before. The old chalk mark was erased, and after measuring the specimen the crank was turned uniformly until the scale again lifted at 4000 pounds, when it was stopped, a chalk mark placed as before, and the scale weight moved to 5000 pounds. The crank was then turned till the scale lifted again. The number of turns and fractions of a turn were counted as before, the rate of turning being as uniform as possible and, as nearly as could be judged, the same as before. This process could of course have been carried on until the specimen broke.

In the case cited, the number of turns of the crank between tensions of 15,000 pounds and 20,000 pounds per square inch (on scale, between 3000 pounds and 4000 pounds) was 5; between 20,000 pounds and 25,000 pounds, a little more than 4; between 25,000 and 30,000 pounds, 4; the number of turns for each additional 5000 pounds gradually became uniform at 3, until a tension of 60,000 pounds per square inch was reached. Between tensions of 60,000 pounds and 65,000 pounds per square inch, the number of turns of the crank was 10, thus plainly showing that the elastic limit had been reached. The elastic strength of the metal was therefore placed at 60,000 pounds. The specimen broke at 108,000 pounds.

The excess of 5 turns, at the beginning of the test, over 3, just inside the elastic limit, was probably due to the fact that the machine grips had not at the beginning gotten a firm hold on the specimen. Previous to the test above mentioned, absolute uniformity in the number of turns at the higher tensions had not been expected, and probably could not be in a poorer machine. In any case, however, some law, according to which the number of these turns increase or decrease, can always be found; and the instant this law is broken the specimen is at its elastic limit.

Uniformity in turning the crank is desirable, in order to prevent shocks in the hydraulic cylinder which might lift the scale. Absolute uniformity, however, is not required, care in turning being all that is necessary.

The time occupied in chalking the wheel and in moving the weight along the scale should be as small as possible consistent with uniformity of interval.

The above method can also be employed in finding the elastic strength for compression. A wrought iron specimen 1 inch in length was subjected to compression. Below a compression per square inch of 55,000 pounds, the number of turns necessary to increase the compression 5000 pounds was between ¼ and ½. Between 55,000 pounds and 60,000 pounds, the number of turns of the crank was between 1½ and 2, thus plainly showing the elastic limit as before.

LIQUID FUEL FOR TORPEDO-BOAT BOILERS.

Translated from the *Rivista Marittima* by Lieut. J. B. Briggs, U. S. N.

Note.—The article in the *Rivista* is a translation of an article in the *Génie Civil* of Paris, by Jules D'Allest, chief engineer of the Fraissinet Company of Marseilles.

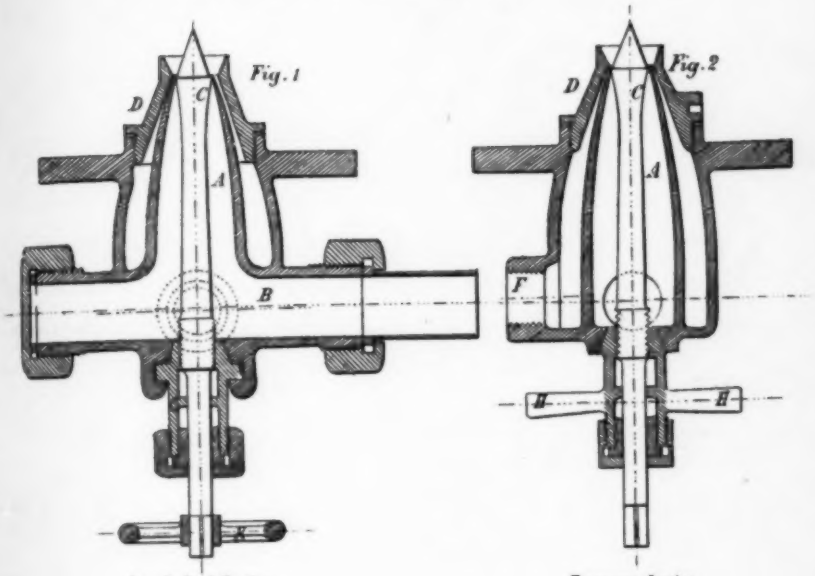
We have published an essay on the heating of boilers by means of naphtha and its residuum, in which we describe our apparatus built for such boilers and the experiments made with the same.

The Ministry of Marine, after having tried (in competition with other similar apparatus) our sprayer on the boilers of the torpedo boat La Chevrette, has recently requested us to study up the subject of a sprayer especially for torpedo boats. In response to this invitation, we have entered again into the consideration of the subject, though from a new standpoint, on account of the element of forced draught, which is an important point in considering ships in which it is necessary at whatever cost to reduce to a minimum the weight of evaporating apparatus in order to gain speed.

Description of the Sprayer.—The sprayer that we have designed for boilers of ordinary draught, and which was experimented upon at Cherbourg, consists of a conical chamber of bronze to which the liquid is conducted through a tube. The mouth of this chamber is closed by the plug *C*, which, managed conveniently by the valve-wheel, can open or close the mouth of the chamber, leaving between its outer conical surface and the inner corresponding surface of the chamber an annular opening varying in width from 0 to 2 mm. Through this annular opening the petroleum penetrates into the furnace in a stream of the shape of a hollow cylinder. The steam, led to the sprayer through a pipe, surrounds the chamber, heating the contents, and, escaping in a stream of cylindrical form through the space before mentioned, surrounds the petroleum, reduces it to spray, and projects it with force into the furnace. This combustible, thus reduced to the finest spray, ignites on contact with any burning body and burns without flame. The force of the fire is regulated by the valve, which can be moved forwards or backwards, thus diminishing or increasing the quantity of hydrocarbon introduced into the furnace.

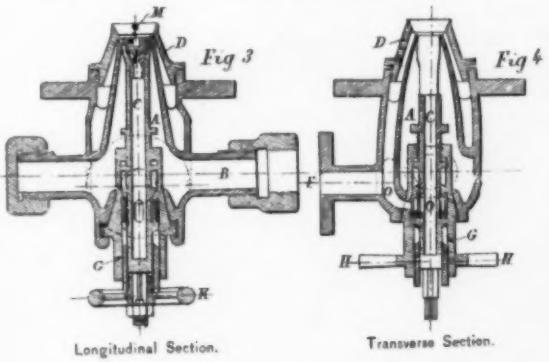
By employing two similar sprayers placed side by side, the control of the fire is rendered very easy. It can be instantaneously extinguished or lighted simply by closing or opening the cock that regulates the admission of petroleum

SPRAYER WITH NATURAL DRAUGHT.



Longitudinal Section. Transverse Section.

SPRAYER WITH FORCED DRAUGHT.



Longitudinal Section. Transverse Section.

in each sprayer. If the apparatus becomes obstructed with solid substances contained in the naphtha, or fouls from lengthy work, it will be sufficient to turn slowly to the right and left the hand-wheel, and thereby regulate the flow of the liquid. If it should be desired to take a look at the interior of the chamber, give a half turn to the hand-lock-wheel and then withdraw the sleeve and the valve.

These sprayers work well and can burn from 10 to 80 kilos of petroleum per hour. A couple of similar sprayers capable of burning 160 kilos of naphtha can then evaporate (in the proportion of 13 liters per kilo of combustible) 2080 liters of water per hour; and supposing that there were an evaporation of 30 liters of water per square meter of heating surface (such being nearly the normal results obtained with ordinary draught), this would correspond to a furnace having a heating surface of 69 square meters. Now, at sea it rarely happens that a furnace has greater heating surface than 50 square meters; it can then be admitted that the apparatus above described, applied to a furnace, can largely fulfill all requirements.

Considering, however, a torpedo-boat boiler, it is necessary to evaporate per square meter of heating surface a quantity of water rather larger than 30 liters, which is possible, of course, having recourse to forced draught. Instead of 160 kilos of petroleum, it might be necessary to burn in one furnace double that quantity, or possibly even more.

To accomplish this, it seems at first sight that it would be necessary to increase the diameters of the apparatus above described; but such is not the case. In fact, with this increase in size, although the petroleum will flow more abundantly into the furnace, still the pulverization will be imperfect, and the result will be incomplete combustion and a dense black smoke, which will foul the boiler and retard evaporation.

To avoid these difficulties, more pulverizing power is necessary. To obtain this, we have added inside the jet of naphtha a second jet of steam. The naphtha thus comes out enclosed by two pulverizing streams, and it all passes in complete spray.

The apparatus that satisfies these conditions is composed, like the first, of a conical box into which the petroleum flows from the tube *B*. The pulverizing agent (steam or air) comes through a tube, and, passing into the cone, forms the external jet that surrounds the petroleum. It also passes at the same time through an orifice into the stem of the regulating valve, from whose mouth it is forced by the cone's mouth into the furnace in the form of a conical stream inside the naphtha. This apparatus is regulated like the first. It can burn up to 400 kilos of naphtha per hour without producing smoke.

It is now necessary to determine the least dimensions to be given to the various parts of a boiler destined to burn a given quantity of combustible, and it is therefore necessary to determine experimentally the greatest evaporation that can be obtained per unit of heating surface both with natural and with forced draught.

Experiments in Evaporation.—These experiments have been made with a return-tube boiler of the type of auxiliary boilers used on the decks of merchant vessels for running windlasses, winches, etc.

The dimensions of the aforesaid boilers are:—

Normal pressure, 3.50 kilos.

Covered heating surface	direct, meters	3.30
	tubular, "	16.70
	Total	20.00
Calorimeter of tubes, square meters		0.1555
Evaporating surface, "		2.57
Calorimeter of smoke-stack, square meter		0.1520
Volume of steam, liters		1130
" water, "		2500

Some necessary changes were made in the furnace. The grate was taken out and was replaced by refractory fire brick, with a bridge-wall to assure the intimate mixture of the gases.

The door and the furnace front are in the case of ordinary draught replaced by a plate, with a door in the lower part, to which are attached the sprayers. The petroleum is fed from a tank placed by the side of the boiler.

With forced draught the furnace is hermetically closed by a cast-iron front, on which are fixed the sprayers, and this has a pipe through which the air is driven by a steam blower into the interior of the furnace. The petroleum is fed to the sprayer by a donkey pump. Two manometers indicate constantly the air pressure.

With natural draught combustion is complete; the petroleum burns without smoke. The fire can be regulated by the sprayers. We have in this way succeeded in evaporating the greatest possible quantity of water, and have reached a limit beyond which we cannot pass either by increasing the number of sprayers or the amount of petroleum.

The following table is a résumé of the experiments:

With Natural Draught.

	Number in Order of Experiments.									
	1	2	3	4	5	6	7	8	9	10
Duration in hours of experiment	4.15	4.10	3.58	3.06	5.20	6.28	4.00	4.36	2.07	5.20
Kind of combustible—Astatki.										
Consumption of combustible in kilos:										
Total—kilos	260.29	210.53	242.37	183.74	283.26	382.78	245.00	267.95	107.18	336 85
Per hour, kilos	61.24	50.52	61.10	59.27	53.11	59.19	61.25	58.25	50.63	63 16
Per sq. meter of grate surface and per hour	69.57	57.40	69.41	67.34	60.34	67.24	69.59	66.18	57.52	71.76
Temperature of feed-water	23°	24°	28°	28°	27°	28°	28°	27°	27°	28°
Pressure in boiler—kilos	3	..	..	..	..	..	..	..	..	..
Water evaporated:										
Total—kilos	3100	2700	2900	2100	3400	4425	2800	3100	1300	3900
Per hour, kilos	729	648	731	677	637	684	700	673	614	731
Per sq. meter heating surface	37.38	33.23	37.48	34.71	32.66	35.07	35.89	34.51	31.48	37.48
Per kilo of combustible	11.90	12.82	11.96	11.42	11.09	11.55	11.42	11.55	12.12	11.57
Same reduced to 100°	13.81	14.85	13.77	13.15	13.83	13 30	13.15	13.32	13.98	13.32

Average quantity of water evaporated per kilo of combustible, 11.83. Same taken at 100° and evaporated at atmospheric pressure, per kilo of combustible, 13.65.

The result of this is that the evaporation reached 37 kilos per sq. meter of heating surface, but that it was not possible to pass this limit. If it were attempted to increase the activity of the fire by increasing the amount of petroleum, smoke would be produced and the evaporation remain stationary.

The greatest evaporation as above obtained is therefore remarkably above that which can be obtained with coal. In fact, with natural draught and using coal of the best quality, the evaporation has never, in the same boilers referred to, passed beyond 28 or 30 kilos for the same unit of heating surface.

The above limit of 37 kilos being reached, it is not possible to increase the rapidity of the circulation of the heated gases in the uptake without recourse to artificial draught, with which it is only possible to obtain a more active evaporation.

Finally, the combustion of petroleum, employing forced draught, is effected without difficulty. The apparatus regulated, and the relations determined between the consumption of petroleum and the quantity of air for combustion furnished by the blower, it is not necessary to attend further to the fire. The

boiler can work indefinitely, the only thing being for the fireman to watch the supply of water and petroleum.

The following table is a résumé of the results obtained in the experiments with forced draught:

Table of Greatest Evaporations with Forced Draught.

	Number of Experiment. 1	2	3
Duration of experiment, hours	1.30	4.30	6.00
Kind of combustible—Astatki.			
Consumption of combustible:			
Total, kilos	213.92	608.44	784.68
Per hour, kilos	142.61	135.21	130.78
Per sq. meter of grate surface and per hour, taking for example a grate surface in the proportion of $\frac{1}{32}$ the heating surface, as in the torpedo boats of 525 horse-power	375	350	344.16
Per sq. meter of grate surface and per hour, taking for example a grate surface like that of the Marceau	331.65	314.44	304.16
Temperature of feed-water	16°	18°	17°
of the smoke-box	350	302	380
of air-chamber	25	20	28
Pressure on boiler, kilos	3	...	...
Water evaporated:			
Total, kilos	2200	7119	9432
Per hour, kilos	1464	1582	1572
Per sq. meter heating surface, kilos	73.20	79.10	78.60
Per kilo of combustible	10.27	11.70	12.02
Per kilo, reduced to 100°.	12.01	13.68	14.06
Pressure of blast:			
In supply-pipe, mm	45	42	45
In tube-box, mm	10	8	8

This last table shows that by the use of petroleum with forced draught the evaporation reaches extremely high limits, a great deal higher than those that can possibly be obtained with coal; and note that by increasing the supply of petroleum and air into the furnace we should have been able to obtain still greater evaporation. That was not possible, it is true, during these experiments, very violent foaming taking place, which, as it was impossible to ascertain the water level in the boiler, obliged us to moderate the activity of the fire; but it would be possible in a boiler capable of withstanding greater pressure than 3 kilos, which we could not go beyond in the boilers employed. As is well known, the greater the pressure, the more foaming is retarded.

Comparison with Coal.—With the boilers of the torpedo boats of 525 horse-power, they succeed at the most in burning 800 kilos of coal per hour, evaporating from 6.5 to 7 liters of water per kilo of coal. Taking the highest figure, the total evaporation is then 5600 liters per hour. These boilers having 100 sq. meters of heating surface, the evaporation per sq. meter is therefore only 56 liters, while the average taken from the table is 76.96 liters. Besides the experiments made with torpedo boats, others more complete were made on shore by the Ministry of Marine with a boiler of the Marceau. In these, in fact, they were able to push the evaporation to the maximum. The boiler had been placed in a room hermetically sealed and connected with the blower.

The following table contains the most important results of the experiments:

Résumé of Experiments of Evaporation with Forced Draught made with Boiler of the Marceau.

	Dates.				
Duration, hours	5	5	4.35	5.3	5.15
Kind of combustible—Mattonelle d'Anzin.*					
Consumption of combustible:					
Total kilos	6610	8235	9013	9980	10,830
Per hour, kilos	1322	1647	1966.52	1976.4	1977.3
Per sq. meter of grate surface and per hour	200.66	250	298.5	300	297.1
Temperature:					
Feed-water	19°	23°	..	11.5°	11°
Smoke-box	440°	491°	481°	524°	514°
In air-chamber	28.5°	34°	..	26°	23°
Pressure in boiler, kilos	6.05	6.05	5.91	6.02	6.1
Water evaporated:					
Total, kilos	55,193	68,185	70,121	78,748.50	83,357.80
Per hour, kilos	11,038.70	13,637	15,298	15,593.80	15,887.70
Per sq. meter of heating surface and per hour.	36.4	44.977	50.457	51.53	52.53
Per kilo of combustible	8.35	8.28	7.78	7.89	8.03
Per kilo of combustible reduced to 100°	9.85	9.77	..	9.468	9.630
Pressure of blast:					
In supply-pipe, mm	20.1	28	66.4	68.5	64.7
In tube-box	1.5	5.8	..	8.7	8.6
Air consumed per kilo of coal burned, mc.	9.73	10.5	11.3	10.27	9.64

* Some kind of prepared fuel in brick shape.

As is seen from this table, the greatest evaporation obtained was 52.30 liters per sq. meter of heating surface.

In the Navy it is often preferable to take as terms of comparison the quantity of coal burned per sq. meter of grate surface rather than the quantity of water evaporated per sq. meter of heating surface.

It is easy to apply this method to a comparison of our petroleum boiler with the coal-burning boiler of the Marceau, taking account of the relative calorific powers of the two combustibles and supposing a grate surface proportioned to the heating surface. With petroleum we have succeeded, in the boilers above described, in evaporating 1582 liters of water per hour. Now, the coal employed with the Marceau's boiler having evaporated a maximum of eight liters of water, if we had employed this combustible instead of petroleum, we should have burned, to evaporate the same quantity of water, $\frac{1582}{8} = 197.70$ kilos of coal.

On the other hand, in the boiler of the Marceau the proportion of grate surface to heating surface being 1 to 46, the hypothetical grate for our experimental boiler will have a surface of $\frac{20}{46} = 0.43$ sq. meters. We should then have burned per sq. meter of grate and per hour $\frac{197.70}{0.43} = 457$ kilos of combustible, or 52 per cent more than that burned in the boiler of the Marceau, which was only 300 kilos.

The comparison with the torpedo boats of 525 horse-power, in which, during the experiments, the fires were pushed to the utmost, brought us to the same results. The boilers of these boats, in fact, evaporate at the most 7 liters of water per kilo of coal, and the proportion between heating and grate surfaces is $\frac{1}{39}$. Besides, there are burned 800 kilos of coal per hour, or $\frac{800}{1.90} = 420$ kilos per sq. meter of grate and per hour, the grate surface being 1.95 sq. meters. Now, if we institute with these boilers the same comparison as that made for the Mar-

ceau, we shall have that our experimental boiler would have burned $\frac{1582}{7} = 226$ kilos of coal on a hypothetical grate of $\frac{20}{52}$ = sq. meter 0.38 surface, or $\frac{226}{0.38} = 594.73$ kilos of coal per sq. meter, and therefore 43 per cent more than that of the torpedo boat.

In connection with the experiments on the Marceau and the torpedo boats above cited, we must for the sake of impartiality cite those that were made some years since in England on the boilers of the Thornycroft torpedo boats, under direction of the English Admiralty, and which were published in *Engineering*.

From the following table (which comprises the results of the final experiments, indicating an evaporation of 84.9 liters per sq. meter of heating surface, with a combustion of 466 kilos of coal per sq. meter of grate) it resulted that the English boilers are more powerful than the French with forced draught, which, it is true, reached 150 mm. of water:

Experiments on Boilers of Thornycroft Torpedo Boats.

	Order of Experiments.			
	A	B	C	D
Duration of experiments, hours	2.00	2.07	1.30	1.77
Quantity (*sic*) of combustible—Cardiff-Nixon.				
Pressure of air in millimeters of water:				
In air-chamber	50	75	100	150
In ash-pit	36.7	57.2	80.5	131.2
In smoke-stack	33.7	46.7	75	108.2
Number of revolutions of fan	575	665	818	986
Temperature, Centigrade:				
On deck	8°	14°	9.5°	14.45°
Air-chamber	23.9	29.5	25.5	27.7
Smoke-stack	578	644	682	784
Of feed-water	12°	14°	12°	13.3°
Pressure of steam, kilos	8.2	8.2	8.07	8.07
Quantity of coal consumed:				
Per hour, kilos	416	529	662	816
Per hour and per sq. meter of grate,* kilos	237	302	378	466
Water evaporated:				
Per hour, liters	2940	3496	3196	4878
Per hour and per sq. meter of heating surface,† liters	51.2	60.0	73.1	84.9
Per kilo of coal	7.06	6.60	6.33	5.97

* Grate surface, 1.75 sq. meters.
† Heating surface, 57.40 sq. meters.

We shall be very careful not to throw doubt on the abilities of the engineers who directed the experiments tabulated above, but it must however be admitted that the results obtained by them cannot be accepted without great allowance, especially in regard to those marked D, whose duration was too short to inspire much confidence. The engineers who had to conduct trials of steam engines in England know that the short duration of a trial greatly diminishes its value, and that in general the results obtained under normal conditions are somewhat inferior to those obtained on the trial. On the other hand, no one can doubt the knowledge and experience of the engineers of the French marine; therefore, in spite of the English experiments, we persist in believing that what the French have obtained with French boilers represents truly the maximum that can be obtained.

We do not believe that, excepting those made by us and before explained, there have been any other experiments on the combustion of petroleum with forced draught; at any rate, our experiments, though incomplete, show (leaving out of consideration the English trials) that with the same draught, the boiler burning petroleum has an evaporating power much superior to one burning coal; and here we propose to show, calculating the volume of air necessary to combustion, not only the volume of the products of combustion in the two cases, but that such superiority is fully supported by theory.

Volume of Air Necessary to Combustion.—Carbonic acid being formed of 27.36 parts of carbon and 72.64 of oxygen, it will require to burn a kilo of coal, obtaining all the carbonic acid, $\frac{72.64}{27.36} = 2.65$ kilos of oxygen, or $\frac{2.65}{1.43} =$ mc. 1.85 of oxygen, 1.1026 being the density of the oxygen, and 1.30 kilos the weight of a cubic meter of air. Now, air being composed of 21 per cent oxygen and 79 per cent nitrogen, there will be required to burn a kilo of coal $\frac{1.85 \times 100}{21}$ = mc. 8.88 of air. Burning hydrogen will form water, which contains 11 per cent hydrogen and 88.9 oxygen. There will therefore be required to burn a kilo of hydrogen $\frac{88.9}{11.1} = 8$ kilos oxygen, or 5.594 mc. of oxygen, or 26.638 mc. of atmospheric air.

Crude naphtha, or its residuum, which we are considering as a combustible, containing about 87.1 per cent of carbon, 11.7 per cent of hydrogen, and 1.2 per cent of oxygen, the volume of air necessary to the combustion of a kilo of this combustible will therefore be $0.871 \times 8.88 + \left(0.117 - \frac{0.012}{8}\right) 26{,}638 =$ mc. 10,800. Now, Péclet has found experimentally that when a combustible is burned on a grate, the best results are obtained when there is introduced into the furnace a volume of air 33 per cent greater than that theoretically sufficient. It is true that in the combustion of naphtha, the mixture of the combustible with the air being very intimate, it is probable that the theoretical amount will be sufficient. However, in order to have plenty of air we shall accept the surplus.

The quantity of air to introduce into the furnace to burn a kilo of *astatki* will therefore be $10.8 \times 1.33 =$ mc. 14.36.

But, to burn a kilo of coal, 8 cubic meters of air are necessary; there will be, then, applying the indicated per cent of increase, $8 \times 1.39 =$ mc. 10.64.

This volume, as a result of the table in regard to the Marceau experiments, is sensibly equal to that obtained in practice.

Volume of the Products of Combustion.—With equal temperature and pressure, the volume of carbonic acid evolved in the combustion of coal is equal to the volume of the oxygen that formed it.

A kilo of hydrogen requiring for combustion 8 kilos of oxygen, it results that each kilo of oxygen consumed will give 1.125 kilos of water-vapor, or $1.24 \times 1.125 = 1.4$ mc. (about) of vapor reduced to zero.

At atmospheric pressure, and 0°, a kilo of oxygen occupies a volume of mc. 0.70, while each kilo of oxygen converted into vapor increases in volume by mc. $1.4 -$ mc. $0.7 =$ mc. 0.7. In other terms, burning hydrogen, the volume of vapor produced is double the volume of oxygen employed. Burning a kilo of *astatki*, the products of combustion will then be $0.87 \times$ mc. $1.85 =$ mc. 1.609 carbonic acid, $0.117 \times 2 \times$ mc. $5.6 =$ mc. 1.310 of steam; and when mc. 14.36 of air are used (of which mc. 1.609 of oxygen has been used to burn the carbon, and $\left(0.117 - \frac{0.012}{8}\right) \times$ mc. $5.6 =$ mc. 0.646 to burn the hydrogen), there will remain an excess of 14.36—1.609—0.646 = mc. 12.105 of nitrogen and oxygen not combined.

The total volume of the products of combustion of a kilo of *astatki* will then be $12.105 + 1.609 + 1.310 =$ mc. 15.024.

This volume is calculated at 0°; we must therefore refer it to the temperature of the furnace and to that of the smoke-stack if it is to serve as the basis of calculation of the respective sections. This correction is not, nevertheless, necessary, being useful instead to serve to establish the following comparison between petroleum and coal boilers.

Comparison between the Power of Evaporation of Coal-burning and Petroleum-burning Boilers.—In a boiler burning coal, to consume a kilo of combustible there must pass into the uptake mc. 10.64 of products of combustion to evaporate the maximum of 8 liters of water. In a boiler burning petroleum, however, to burn the same quantity of combustible it is necessary to consume mc. 14.36 of the same products; therefore 13 liters of water are evaporated. In other words, to evaporate a liter of water it is necessary with coal to circulate in the boiler $\frac{10.64}{8}$ = mc. 1.330 of air, and with petroleum $\frac{14.36}{13}$ = mc. 1.104. Or, for the circulation of one cubic meter of gas in the flue, the boiler evaporates, employing coal, $\frac{1}{1.330}$ = 0.75 liter water, and employing naphtha, $\frac{1}{1.104}$ = 0.90 liter. The result of this is that, with equal sections of tubes, and consequently equal heating surface, and with same conditions of draught, with naphtha the same boiler evaporates 0.0—0.75 = 0.15, whence $\frac{0.15}{0.75}$ = 20 per cent more than with coal.

It therefore also follows that to evaporate the same quantity of water in a unit of time with the same draught, the petroleum boiler can be 20 per cent smaller than the coal-burning boiler. Now we have found in practice a still greater difference, caused by the fact that in burning coal there is introduced into the furnace a much greater quantity of air than is theoretically necessary; while with petroleum, on the contrary, this quantity of air is reduced on account of the intimate union of the combustible and the supporter of combustion (air in this case), and on account of the uniform flow of the two, all which brings the combustion nearer the theoretical conditions. This observation, and the comparison previously made between the products of combustion in the two cases, explain the considerable evaporation that we have demonstrated in our experimental boiler.

[NOTE.—A section on the inconveniences attending the use of the present type of torpedo-boat boiler is omitted here.—TRANSLATOR.]

Boilers burning Petroleum under Forced Draught.—In view of the difficulties attending the use of coal with forced draught, and of the dangers of the usual type of torpedo-boat boilers, the question naturally arises, why not agree to experiment on a vast scale and seriously in regard to the employment of petroleum on board those vessels, using a boiler specially adapted to that combustible?

This idea was, it is true, first brought out by the *Compagnie des Forges et Chantiers*, of Havre, which had also taken out a patent. Unfortunately, however, this company (although improving and modifying) had appropriated the idea of a petroleum grate of Sainte Claire Deville, who was satisfied with making the petroleum flow into the furnace through little pipes slightly inclined. Now this could not be a satisfactory solution of the problem. Indeed, in the apparatus of the company of Havre, the air employed had a pressure of 8 or 9 centimeters only, which, as we shall better see presently, is wholly insufficient to effect the pulverization of the combustible, so that the combustion was effected by simple contact. Naturally the result obtained was very mediocre; the production of steam was very feeble; the apparatus was very likely to foul; so that after a few experiments the system was abandoned without receiving any further application. The experiments that we have described in the beginning of this study show that, using the pulverizers, the problem is solvable with certainty of good results.

The boilers in actual use could be replaced by others with closed furnace, whose general form might be the same, and whose dimensions might correspond to the figures that ought to be adopted in the torpedo boats of 525 horse-power. In these boilers, as soon as the grate is done away with, the furnace, instead of being square, would have the same form as the fire-box, so that the shell of the boiler would be cylindrical throughout its length.

There is no doubt that a similar boiler, fed with petroleum, would be wholly free from the danger of blisters, which form in plates of coal-burning boilers. The presence of an opening in the hearth would make it elastic, thus eliminating the danger from grooving and cracking (of plates). Moreover, this elasticity, permitting the tube-box to expand and contract independently of the shell, would certainly diminish the danger of steam escaping from the tube-sheet. This, however, would still be directly exposed to the flames.

But it is to be noted that doing away with the grate permits the construction of a return flue in the petroleum boiler. Now, a boiler constructed on this plan would probably work very well, even with extreme forced draught; a fire-box of the kind adopted in the boilers of the Marceau would allow expansion, and the tubes would be secure against the flame impacts that they receive when placed in the prolongation of the back connection. In both these boilers the front part of the furnace is made of a cast plate, which, that it may not get red hot, has water circulating inside. The pulverizers are fixed on this plate, and receive the petroleum from a reservoir placed at the boiler's side; and the pulverizing agent (steam or compressed air) comes to the pulverizers by means of a tube.

The air, forced by the blower, arrives at the pulverizers by means of a fitted pipe, and divides in two currents that penetrate to the furnace through the orifices. These two currents meet the jet of burning naphtha at right angles, a disposition that secures the intimate commingling of the two, and which, as we may be able to prove experimentally, gives results much better than those obtained by sending the blast in the same direction as the petroleum.

This disposition has also another advantage: the blast of air coming at a right angle loses some of its velocity, which in the furnace becomes $\frac{q}{\Omega}$ (Ω being the section of the furnace) instead of $\frac{q}{\omega}$ (ω being the section of the supply-tube), which it was at the mouth of the tube. This diminution of velocity allows the heated gases to remain longer in the furnace and the tube-box, and therefore to give up more completely the heat they contain. A door allows the entrance of air into the furnace when it is desired to resort to natural draught, and two other smaller doors allow the introduction of balls of burning cotton to start fires.

The boiler with direct tubes has the same dimensions and the same weight as the boilers in use on the 525 horse-power torpedo boats.

The return-flue (or flame) boiler is a little heavier than the other; but it must be noted that naphtha having much greater power than coal, the dimensions might (for same steam power) be notably reduced.

The boilers considered above answer the following conditions:

	Direct tube boiler.	Return-flue (or flame) boiler.
Normal pressure, kilos	9	9
Total covered heating surface, sq. meters	99.50	98.80
Tubular section inside of tube ferrules, sq. meters	0.22	0.22
Diameter of tubes	40 × 44	46 × 50
Distance between tube-sheets	2.850	3.45
Number of tubes	238	166
Total evaporating surface, sq. meters	6.23	6.45
Same per horse-power, sq. meters	0.0119	0.0123

	Direct tube boiler.	Return-flue (or flame) boiler.
Proportion with heating surface	$\frac{1}{16}$	$\frac{1}{15}$
Volume of steam, mc.	2.640	2.720
Volume of steam per horse-power, liters.	5	5
Volume per sq. meter heating surface.	26.4	27.15
Weight of steam consumed per hour for 525 horse-power (at 10 kilos the horse-power), kilos.	5,250	
Weight of petroleum to produce this steam per hour, kilos.	437	
Volume of air necessary per hour, in the ratio of 23 cubic meters per kilo of petroleum	8740	
Same necessary per second	2.427	
Section of air-supply tube, sq. meters	0.1213	
Velocity of air per second in supply-tube, meters	20	
Pressure of blast in col. of water, $h = \frac{V2}{2g} - \frac{\delta^1}{\delta}$	0.026	

Arrangement of Boilers and Petroleum Reservoir.—The arrangement is most simple. The fire-room can remain in free communication with the outside air. The blower sends into the furnace the necessary air for combustion by means of pipes. The remainder of the arrangements are not changed. The petroleum tanks are tin, and are situated on each side of the boiler, where the coal-bunkers usually are. A reserve deposit may be made by covering over with thin plating the frames of the ship. A special donkey-pump conveys the oil from the deposits to the reservoirs for distribution to the pulverizers.

Substitution of Compressed Air for Steam in Pulverizing the Petroleum.—On board a torpedo boat, the water supply being limited, it would be highly inconvenient to employ steam as a pulverizing agent, as the amount required would equal one twentieth of the amount the boiler could produce.

But this inconvenience can be obviated by employing air instead, with which the pulverizing is effected equally as well as with steam; and, besides, a whiter flame is produced, especially when using heated air, while the result is sensibly the same as with steam. Employing cold air, the apparatus sometimes gets extinguished suddenly, which does not happen with heated air, especially if the furnace is fitted with refractory brick, which get red hot rapidly, thus assuring perfect regularity in the fire.

The temperature to which it is necessary to heat the air is not very great; 50° or 60° will be enough. It would be well to lead the air through the steam-space or the smoke-stack. Employing air on lighting the fires, a greater pressure must not be used than 0.400 to 0.600 kilo. The fires well under way and the furnace hot, the pressure can be increased to one kilo; but the best average pressure is 0.75. It is to be noted, however, that with compressed air the flame produces continuous roaring, rather intense, similar to the noise of a large blower. This phenomenon, which is not noticed when steam is employed, is probably due to a succession of lighting and extinguishing which follow at very brief intervals, and must have the same origin as those produced by the "chemical harmonic" tubes; it is therefore probable that it would be done away with if, instead of using atmospheric air, we were to employ the products of combustion. This can be easily done, and as these products escape from the smoke-stack at a high temperature, the necessity of heating will be done away with; it would even be necessary to cool them so as to avoid damaging the pump. This cooling, however, must not be carried too far, since the gaseous products contain watery vapor from the combustion of the hydrogen which might tend to impede pulverization. Some months ago, in England, there was much said in regard to the employment of compressed air as a pulverizing agent, putting the idea forward as a new and great discovery. The talk was all for nothing, since every time that steam has been employed in

pulverizing a liquid, the question has been considered as to the employment of air or some compressed gas to obtain the same results. We, ourselves, some years ago conducted trials in pulverizing with compressed air. The *Forges et Chantiers* at Marseilles, up to 1883, experimented with a pulverizer imported by the Russian Admiral Likatchoff, in which they substituted compressed air for vapor. This application in fact offers nothing new.

Volume of Air necessary to Pulverization, and Volume of the Compressing Pump.—To pulverize one kilo of naphtha we must have about 500 liters of air at a pressure of .75 kilo.

As the boilers of the 525 horse-power torpedo boats should burn at the most, at full speed, 300 kilos of naphtha per hour, a pump capable of furnishing 300 cubic meters an hour, or five cubic meters a minute, will give a volume of air more than sufficient to assure the pulverizing. A direct-acting Westinghouse pump of 300 mm. diameter, with a stroke of 300 mm., running at 60 revolutions, will be sufficient for the work.

Air-Tank for Use in starting Fires.—For starting fires it will be necessary to have a reservoir containing compressed air which will arrive at the furnace at a pressure of 0.75 kilo by means of a pressure-regulator. The capacity of this reservoir can be easily determined, knowing the quantity of naphtha to pulverize in order to obtain in the boiler steam at a tension sufficient to work the pump.

The boiler contains 2850 liters of water, which it will be necessary to heat to 130°, corresponding to the pressure at which the pump can begin work; but it must be observed that until the pressure in the boiler is obtained, the air comes in at ordinary draught, and consequently the quantity of combustible burned is much less than when the fires are well under way. It thence results that the volume of heated gases, being smaller, pass only through the upper tubes, so that the lower part of the boiler is still cold while the upper part is already under pressure. Therefore we can count on being obliged to heat only 2000 liters, instead of 2850, without danger of falling below limits.

To increase the temperature of the 2000 liters to 130°, supposing the air of the boiler at 10°, it will be necessary to consume $2000\ (130 - 10) = 240{,}000$ heat units. The volume of steam contained in the boiler being 2640 liters, it will be necessary, in order to refill it with steam at 130°, to evaporate mc. $2640 \times 1.50 = 3960$ kilos, or 4 liters of water taken at 130°, and convert them into steam at the same temperature. The consumption of heat by this evaporation will be

$$\lambda = (606.5 + 0.305\ T - T)\ 4$$
$$= (606.5 + 0.305 \times 130 - 130)\ 4 = 2064.60.$$

The total number of heat units to be consumed to put the boiler under pressure will therefore be $240{,}000 + 2064.60 = 242{,}064.60$. Naphtha producing about 11,000 heat units per kilo, it will be necessary to consume $\frac{242064.60}{11000} = 22$ kilos naphtha, and therefore to use $22 \times$ mc. $0.500 = 11$ cubic meters of air at a pressure of 0.75 kilo.

If we take a 120-kilo reservoir, like those on board the torpedo boats for charging torpedoes, the capacity of the reservoir will therefore have to be $\frac{11 \times 0.75}{120} =$ mc. 0.068.

Résumé of the Advantages in employing Naphtha on Torpedo Boats.—From what has been said, it is seen how easily the boilers of torpedo boats can be heated with petroleum, and it is easy to evaluate the considerable advantages that arise from this system.

As we have before observed, by removing the air-chamber from in front of the boiler, not only shall we do away with the depressing moral effect to which the firemen are now subjected, but we shall also avoid an actual danger liable to occur at any moment. The management of the boiler will be most simple,

resolving into a mere watching, instead of requiring as at present a numerous personnel who must be experienced men and who are difficult to obtain.

From a military point of view, it is to be remarked that with a non-smoke-producing fuel like petroleum, a torpedo boat would not be seen from afar, as happens at present—in the daytime, on account of the streams of smoke; at night, on account of the burning material escaping from the smoke-stack. Naphtha having a calorific power greater than that of petroleum, its employment would permit, with the same weight of combustible taken on board, a longer stay at sea. In fact, coal, evaporating in the torpedo boats 7 liters of water, and naphtha 12 liters, the distances run, with equal amounts of the two combustibles, would be in the proportion of $\frac{12}{7}$; that is to say, if the torpedo boat using coal runs x miles, the one using petroleum would run $x \times \frac{12}{7}$ miles.

We have also already said that with equal heating surfaces the petroleum boiler can evaporate 20 per cent more than the coal-burning boiler; therefore we could build a petroleum boiler which would be 20 per cent lighter than a coal-burning boiler of same power.

The boilers of this last system for torpedo boats of 525 horse-power, weighing 8000 kilograms about, would probably decrease the weight of the torpedo boat by about 1600 kilograms, which would allow, still having the same power of boiler, a sensible increase of speed.

Besides the wholly peculiar interest that heating by petroleum presents in the question of torpedo boats (in which it is necessary to sacrifice everything to speed, even at the cost of having a useless weapon), it is also to be remarked that the substitution of naphtha for coal solves in a simple and practical way the problem of forced draught, to which constructors are constrained to pay attention in answer to the always increasing demands in regard to the speed of steamers.

The employment of this combustible would also permit notable reductions in the dimensions of the immense boilers that must be employed when it is desired to obtain great speed. If to this is added the economy of personnel and space that results from using this combustible, it is seen that this is an excellent reform which must not be lost sight of, and which will perhaps be generally adopted in the near future.

However, first of all, it is necessary to resolve the difficulty of a supply of naphtha. The question is not insolvable, and we even believe that we are on the eve of a definite solution. It creates, in fact, such an interest as to form daily subject for discussion and studies so important that probably we shall have occasion at another time to take the question up for examination.

GUN-MAKING IN THE UNITED STATES.*

By Captain ROGERS BIRNIE, JR., Ordnance Department, U. S. Army.

[Reviewed by Lieutenant A. GLEAVES, U. S. N.]

In this permanently valuable book the author "aims to give a history of gun-making and gun trials in the United States, with special reference to the part taken therein by the War Department in the past fifteen years." The first half of the book is devoted to the consideration of the cast iron period, which continued until about 1872, and then in natural order are discussed the succeeding ten years of experimentation. The last two chapters on steel cast and forged built-up steel guns are of special interest at this time of burning questions as to what shall be the ultimate accepted type of gun. They contain a clear and concise mathematical discussion of the theory of the construction of steel cast guns, and descriptions of experiments conducted by the Ordnance

*Monograph VIII., Military Service Institution of the United States.

Department for the purpose of investigating the principles of mechanical engineering involved in the construction of built-up steel guns. There is also an admirable diagram, drawn to scale, graphically illustrating the changes "in radial dimensions" which took place in assembling the 8-inch gun. "The degree of accuracy obtained (in shrinking) was 98 per cent of the mathematical result anticipated."

In a book which deserves only praise it may seem captious to find fault, but the curve of powder pressure which is plotted on the plan of the 8-inch B. L. steel rifle shows a muzzle pressure of only 2.9 tons, while the elastic resistance curve at the same point is 955, hence the factor of safety at the muzzle is 3.3, which is out of all proportion to that at the breech, where it is only 1.5. If therefore these curves are correct, it is not clear why the gun should be hooped to the muzzle as Captain Birnie states is now done. The latter half of the book especially merits the careful study of every one interested in guns and gun-making.

Appendix C, on the "alleged failure of steel guns," enumerates fourteen well known and often quoted accidents to certain guns, with counter statements which show that in not a single case has there been a failure of the modern type of built-up steel guns.

Whatever Captain Birnie writes on the subject of guns demands attention, and his arguments in favor of the built-up system carry with them the weight of recognized authority.

During the war, and for a few years afterwards, the superiority of our shell guns was unquestioned, but when the question of penetration and power of guns arose, and cast iron was proved by actual trial to be an unsuitable metal for guns, we commenced to fall behind the rest of the world and have never regained our place, although in a fair way to do so now.

Our ordnance history in the seventies is somewhat brighter. It is marked by the conversion of the old and "comparatively worthless" smoothbores of large caliber into rifled muzzle and breech loaders, and whether it was a mistake or not to attempt the development of *both* systems, a gun was evolved of indisputable worth. Notwithstanding the 8-inch M. L. R. converted from the 10-inch S. B. (Army) was an acknowledged "makeshift," and is not to be compared with the modern type, its energy is sufficient to penetrate the armor of "a large proportion" of the war ships of the world, and upon it we must depend for some time to come.

About 1872 the revival of the gun question by the discussions and investigations of the various Boards and Ordnance Committees appointed to consider the subject, brought forth many private inventions of more or less merit, some of which excited much interest and comment in the press throughout the country. It is sufficient to mention two, the multicharge gun and the wire-wound system. Interesting accounts are given of the trials of both. The former finally failed at Sandy Hook in 1883–84. The wire-wound gun (10-inch) burst after the 93d round, but the system impressed the Board as possessing sufficient merit to warrant the recommendation of further experiments.

In 1871 "the trials of cast iron rifles, pure and simple, were practically abandoned," but twelve years afterwards, in accordance with the act of 1883, the War Department was obliged to design a 12-inch B. L. R. of cast iron. It was a strange recommendation of the Logan Committee, in the face of experience with this metal abroad, where it had been discarded by all the gun-making powers after exhaustive trials. One is reminded of the backward step taken in England when, after a trial of five or six years, breech loaders were superseded by muzzle loaders, to which the English artillerists clung with stubborn persistency for fifteen years, when they were compelled to return to breech loading.

In the matter of ordnance the Navy has been more fortunate than the Army, and it is pleasant to read the generous credit Capt. Birnie accords to the Navy for its success in steel-gun building. Since the inauguration of steel, in

1883, the Naval Bureau of Ordnance has not been hampered with the construction of any guns other than steel. The Army, on the other hand, has not yet been permitted to shake off its fetters of cast-iron. The cast-iron 12-inch B. L. R. (model of 1883) has been completed and proved at Sandy Hook. "Taking the average result—charge 265 pounds, projectile 800 pounds, pressure 28,000 pounds, and M. V. 1750 f. s.—we find the power of this gun is represented by a M. E. of 1700 foot tons nearly." This performance Captain Birnie says, "entitles it to be classed as a safe medium power gun of the caliber," but also states that "the bore was so badly scored by erosion that at the 96th round the Board did not consider it safe to continue the firing."

"Including the rifle mortars there are three different types of combined cast iron and steel guns in hand at the present time, viz. a 12-inch B. L. R., mainly of cast iron, but lined with a steel tube inserted from the rear and forming about one half the length of the bore; a 12-inch B. L. R. with cast iron body, strongly reinforced by a double row of steel hooping extending from the breech to a distance forward of the trunnions—the trunnions themselves forming part of one of the hoops—and a steel tube lining as in the first gun; and two 12-inch rifled mortars alike in general construction, but one a muzzle loader and the other a breech loader." There are also two 10-inch B. L. wire-wound guns partly constructed, one with a tube of cast iron, the other with a tube and longitudinal bars of forged steel. "The 10-inch wire-wrapped cast iron rifle will have 28 calibers length of bore and weigh 29 tons." The 10-inch steel gun will weigh 22 tons and have a bore 30 calibers long. The peculiar feature of this gun will be the longitudinal bars which are intended to give it longitudinal strength. They will encircle the gun like a cylinder and extend from the breech to about one half the length of the gun.

The 12-inch mortars are short rifled pieces; they weigh about 9 tons, have a charge of 52 lbs. and throw a 610-lb. shell a distance of very nearly five miles.

Forged built-up steel guns were authorized by Act of Congress in 1883, and one year ago an appropriation of $20,000 was made for the manufacture of three steel-cast 6-inch guns; one to be of Bessemer, one of open hearth, and another of crucible steel. The last was not bid for; the first has been cast at Pittsburg, and is said to be nearly ready for shipment to Washington, where it will be finished and then sent to the proving ground at Annapolis for proof and statutory tests.

"The trial of one 6-inch steel cast gun of a given make may prove something in regard to 6-inch guns, but in the face of past experience and present widespread distrust of the suitability of unforged (or unpressed) steel guns, can do little to predicate what result will be obtained with larger calibers."

"Another great necessity for making the small calibers at present appears to lie in the capacity of steel works for making such castings, for there is no doubt but that a special plant must be yet provided for making the larger calibers of steel cast guns. This is one of the items of expense which, combined with others, will probably make the cost of production of a gun of large caliber quite as expensive if made in this way as if made of forgings and built up.

"The amount of metal used for the hollow castings made or attempted for 12-inch cast iron rifles was about 240,000 pounds, or somewhat more than double the weight of the finished piece. The rule of double the weight holds good in heavy steel castings. Taking for example a 12-inch steel gun, the heaviest casting required for a built-up forged steel gun of this caliber is 40 tons, to be cast in the simplest form of a solid ingot. This gives a rough finished forging of 14.5 tons weight, also less than half that of the casting. Applying these rules to the massive casting of a 12-inch steel cast gun, the weight of casting if made hollow would exceed 100 tons, and if made solid would exceed 120 tons at the least estimate allowable. And for this massive casting a special plant, flask, and all the adjuncts must be provided. If we go to 16 inches caliber, the comparison is 84 tons as the heaviest casting for the forged steel

gun against not less than 250 tons for the steel cast gun. Considering the extreme difficulty of making sound steel castings of even a few tons weight at the present time, how long may it be before such castings as these can be manipulated? For guns of such caliber, then, it may be said the steel cast system is, from present lights and practices, a question of the future.

"The feasibility of making castings for steel cast guns up to 10-inch caliber (weight of casting about 60 tons) seems within reach of appliances that might be readily provided, but that such guns, or even smaller ones, can be made of good sound material possessing the requisite physical qualities to compare in strength, endurance and power with built-up forged steel guns of the same caliber, cannot be conceded. To even approach this it would be indispensable that the steel cast gun should be made with the proper degree of initial tension. The Rodman method of casting has been proposed, but whether intended to accomplish the introduction of initial tension or not has not been made quite clear by its advocates. The slow process of cooling incident to this method would cause the formation of large weak crystals in the casting, and, apparently recognizing this, the advocates of the method have proposed to remove all the initial tension strains by an after annealing. This would, moreover, appear to be a wise precaution, inasmuch as this method of casting is so uncertain in cast iron and would be much more so in steel, with its greater shrinkage and liability to crack from internal strains in casting. If, then, the Rodman method is not used for the purpose of introducing initial tension, the hollow casting is certainly a bad form, as proved by Whitworth's trials and tribulations with it. The unsoundness found in the centre of a solid cast ingot is in this case only transferred to the middle of the walls of the gun—a result in every way bad and which no subsequent treatment can correct."

It should be a matter of congratulation in this country that the highest type of the modern gun is the embodiment of American ideas. The breech closure, the benefit of the principle of initial tension, the shrinkage of layers of cylinders over each other, were all the original conceptions of our own people, although each system was developed abroad.

The first built-up forged steel gun constructed in the United States was begun in 1879 at South Boston for the Navy Department. It was completed in 1882 and proved at the Naval Experimental Battery. It was an experimental gun of medium power and its mark was not duplicated. It did its work well and was the beginning of what may be called the steel age of our naval ordnance.

"Since the commencement of the active work allowed by appropriations in 1883 and subsequent years, the Navy Bureau of Ordnance has procured the forgings for, and completed or nearly so, twenty-one 6-inch, eight 8-inch and two 10-inch rifles. Work on a third 10-inch rifle, to be 34 calibers in length of bore, has been commenced, with forgings now at the Washington Navy Yard.

"Of these guns the West Point Foundry contracted for the manufacture of five 6-inch and two 8-inch rifles. Four of the 6-inch are completed and the remaining guns are in the final stage of construction. The South Boston Iron Company contracted for the manufacture of six 6-inch and two 8-inch rifles. Five of the 6-inch are completed, and the two 8-inch are to be completed in March, 1888.

"The Washington Navy Yard has completed two 5-inch, ten 6-inch, four 8-inch and one 10-inch rifles, and has another 10-inch about three-fourths completed. Carriages for all these guns have also been made there, besides a number of 3-inch guns and projectile work.

"At present the Washington Navy Yard has worked up its plant to a capacity for a yearly produce of twenty-five 6-inch and ten 8-inch guns and carriages. Plans are now in process of development which will make the yearly capacity of the Yard equal to completing twenty-five 6-inch, four 8-inch, six 10-inch and four 12-inch rifles, or a proportionate number of any given calibers.

"In their main features the Navy and Army steel guns are alike, the most

important difference in construction being that, in the Navy guns, the trunnion hoops are made of oil-tempered and annealed castings and are screwed on cold, while in the Army gun designs these hoops are forged and assembled by shrinkage. In the matter of charges also the practice differs, in that the rule in the Navy is to use a charge of powder equal to about one half the weight of the shot, while in the Army the weight of projectile is made proportionately much heavier. The lighter projectile gives a high velocity with a relatively flat trajectory, which is best adapted, as it is claimed, to the conditions of naval combat."

The excellence of the new Naval guns is shown in the following table compiled from the official firing sheets:

	Weight in pounds.	Length of bore in calibers.	Weight of powder charge.	Weight of projectile.	I. V. F. S.	Pressure in tons.	Date of Firing.
5-inch steel B. L. R....	6200	24.6	32	60	2046	15	Aug. 1887.
6-inch " " ...	11,000	24.4	54	100	2105	15.6	Mar. 1886.
8-inch " " ...	28,000	24.6	112	250	2024	15.2	Nov. 1887.

BIBLIOGRAPHIC NOTES.

AMERICAN CHEMICAL JOURNAL.

VOLUME 10, NO. 2, MARCH, 1888.

J. P. Cooke, assisted by T. W. Richards, with the view of testing Prout's hypothesis, has redetermined the atomic weight of oxygen by the combustion of weighed amounts of hydrogen. The mean of sixteen determinations gives $O = 15.953 \pm 0.0017$ ($H = 1$). H. N. Morse and W. M. Burton find that the hydrogen formed by the dissociation of water at the temperature of the oxidizing flame will diffuse through platinum. This would account for various cases of reduction in platinum vessels hitherto unexplained. F. G. Novy has prepared some of the higher homologues of cocaine. C. R. S.

ANNALEN DER HYDROGRAPHIE, ETC.

PART I, 1888. The surface currents in the southwestern part of the Baltic, and the influence of the wind. Remarks on Fitzroy river and its navigation to Cooktown, east coast of Australia. Observations on the west coast of Africa between Burguela and Mossamedes, from report of commander of German gunboat Habicht. Extracts from cruise reports of Captain Nichelson from Port Natal to Port Adelaide. Barasona, Pinta Palmas, Petit Tron, on the south coast of Hayti. Contributions to the description of the coast of Kaiser Wilhelms Land. Daily and annual variations of force and direction of the wind on the island of Lisma, explaining the character of the Bora and the Scirocco. A few magnetic observations in the North Sea. Instrument for determining the position of the ship near shore (description of the Rittenhouse chart table and position finder). Meteorological and hydrographic notes.

PART II, 1888. Variations in the height of water in the Caspian, Baltic, and Black seas, with reference to the weather. Observations of temperature, specific gravity, transparency and depth of water and character of bottom in the Baltic and North seas. Notes on the navigation on the west coast of Africa. The calculation of the deviation of the compass, with investigation concerning the first observations of Capt. Flinders. Quarterly review of weather observations by the Termen Meteorological Bureau. Meteorological and hydrographic notes. J. T. S.

ENGINEER.

JANUARY 27, 1888. Riggs high speed revolving steam engine; illustrated.

FEBRUARY 3. Forced draught; letter.

FEBRUARY 10. On the construction of furnaces for burning liquid fuel; illustrated. Forced draught; editorial.

FEBRUARY 17. Bennett's geometric compasses; illustrated.

With this instrument, ellipses of any size or shape, polygons and other geometrical figures can be drawn as readily as circles with ordinary compasses.

On the combustion of coal, and some evaporative experiments with natural and forced draught.

FEBRUARY 24. On the construction of furnaces for burning liquid fuel. Nordenfelt submarine torpedo boat. Quadruple expansion engines of the S. S. Suez; illustrated.

MARCH 2. Do marine boilers supply wet steam?—editorial.

MARCH 9. On the construction of furnaces for burning liquid fuel; illustrated.

MARCH 16. The Nordenfelt submarine boat; illustrated.

MARCH 23. The development of the marine engine in the British Navy.

"Since 1885, with a few minor exceptions, all new engines of the navy have been on the triple-expansion principle, and with boiler steam pressures of at first 130 lbs. per square inch, gradually increasing to 155 lbs. in 1887. A further gain in economy has thus been effected which is variously estimated. From 15 to 20 per cent over the compound engine of the same pressure is often given as the amount of gain, and probably 15 per cent may safely be taken as not too much."

On the construction of furnaces for burning liquid fuel; illustrated.

MARCH 30. On the relation between power and speed in steam vessels. The Eclipse Corliss engine; illustrated. A new torpedo boat. W. F. W.

ENGINEERING.

JANUARY 6, 1888. Naval manœuvres; editorial.

JANUARY 13. Rapid firing arms.

JANUARY 20. The Howell torpedo; editorial. The torpedo boat Fatum.

This boat, built by Orlando & Bro., of Leghorn, has given remarkable results as regards manœuvring power, steaming and steering astern.

Torpedo boat casualties.

A new departure in brazing and welding; letter.

The cheapening of the production of oxygen by Brin's process has put into the hands of metal workers a new power. Brazing can be done quickly with a mixture of compressed oxygen and coal gas, and iron welds made that were not possible with the coal gas alone.

JANUARY 27. Propeller planing machine; illustrated. Electrical welding; illustrated.

A method devised by von Bernados, of St. Petersburg, different from any previous system and seems thoroughly practical. Promises to be especially valuable for repair work in shops and perhaps on shipboard.

Miscellanea.

Messrs. Oswald, Mordaunt & Co. (builders of the engines of the Elbe) still cling to the belief that the bursting of the steam pipe was caused by the water collected in a bend, and are sustained in that opinion by the fact that water did collect in large quantities. This was recently proved by fitting a water trap to the pipe near the bend.

FEBRUARY 3. Brazing and welding with oxygen gas; letter.

The process has been in use some months in London. The gases are under pressure and mixed before arriving at the point of ignition. This gives better results than the ordinary arrangement of the oxy-hydrogen blowpipe.

FEBRUARY 10. Brazing and welding with oxygen; letter.

Describes form and proportions of blowpipe used.

Rapid firing arms (continued).

FEBRUARY 24. Rapid firing arms (continued). W. F. W.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

VOLUME VII, No. 1. Index to current literature.

No. 2. Present aspect of the problem of American inter-ocean ship transfer, by Robert Moore.

A short and interesting review of the canal question.

The calculation of plate girders, by A. Münster.

The author gives three new formulæ for which he claims greater accuracy than is attainable with those in general use.

Index to current literature.

No. 3, MARCH, 1888. Triple expansion engines for lake service. The volt, the ohm, and the ampère.

A paper by Prof. Nipher on the evaluation of the ohm and the relation of the three electrical units mentioned.

Testing the strength of engineering materials. H. S. K.

JOURNAL OF THE U. S. CAVALRY ASSOCIATION.

VOLUME I, No. 1, MARCH, 1888.

The first number of this journal, published by the Association at its headquarters, Fort Leavenworth, Kansas, comes to us replete with useful and interesting information for the cavalry branch of the army. It contains also the constitution and by-laws of the Association, which in their main features resemble very closely those of the Naval Institute. The Journal appears in a very neat and appropriate dress, and the publication committee are to be congratulated upon its handsome appearance. We predict for the Association a prosperous career. C. R. M.

JOURNAL OF THE FRANKLIN INSTITUTE.

VOLUME CXXIV, No. 744. Forbes's electric meters. Flash-light photography.

VOLUME CXXV, No. 745. Early forms of electric furnaces. The gramophone. Electrical measurements, especially as applied to commercial work.

No. 746. A review of progress in the arts and manufactures in 1887.

No. 747. Pig iron; including the relation between its physical properties and its chemical constituents.

No. 748. The pilot chart of the North Atlantic Ocean.

An excellent article contributed by Ensign E. E. Hayden, U. S. N., in charge of the division of Marine Meteorology, United States Hydrographic Office.

J. H. G.

RAILROAD AND ENGINEERING JOURNAL.

DECEMBER, 1887. Spanish cruiser Reina Regente. New Spanish torpedo boats. (Full page illustrations.) J. H. G.

JOURNAL OF THE MILITARY INSTITUTION.

VOLUME IX, NO. 33, MARCH, 1888,

Contains the prize essay for 1886, by Lieutenant M. Woodruff, U. S. Army, entitled "Our Northern Frontiers." This is an interesting paper, full of valuable facts and figures. According to Lieutenant Woodruff, there are five railroad systems in Canada, the largest of which (the Canadian Pacific) is [illegible] miles, and the total number of miles of railroad in operation or under construction is 12,449. The military forces can be recruited from about 900,000 effectives, of which 10,600 could be called out in a few hours. The infantry is armed with the Snyder rifle, and the cavalry with the carbine of the same make. The field artillery is armed with the 16-pounder M. L. gun. There are some 400 S. B. guns and some 7-inch and 8-inch modern rifles for garrison artillery, beside the special armament of Halifax and of Esquimault. The naval force of the Dominion consists of eight armed light draft cruisers, and two unarmed despatch boats.

There are four main systems of water communication, the principal one being that of the St. Lawrence and the Great Lakes. It extends 2259¾ miles, 71 miles of which are canals. Of this system only one canal is in the United States. It is proposed to give the whole chain a navigable depth of 14 feet.

The United States has eleven canals in this section of the country. The greatest depth is 17 feet, and the greatest surface breadth 100 feet. The minimum depth and breadth, respectively, are 4 feet and 18 feet, which give the limits of the dimensions of a gunboat or torpedo vessel that can be transferred from the seacoast to the Great Lakes.

The other articles are: "How to Feed the Soldier," by Major W. F. Spurgin; "System of Defense of the Principal Ports of Europe," by Captain T. Tuttle; and a paper on "Mob and Military," by Lieutenant Young.

The discussion of Captain Birnie's admirable monograph on Gun-making in the United States closes this number of the Journal. It is entertaining reading, but throws no new light either upon that excellent paper or the subject of which it treats. A. G.

JOURNAL DU MATELOT.

APRIL 7, 1888. Petroleum motor for small boats.

A system by Lenoir, showing boat with engine, and interior view of motor.

D. H. M.

MINUTES OF THE PROCEEDINGS OF THE INSTITUTION OF CIVIL ENGINEERS, LONDON.

VOLUME XCI, 1887–88. Notes on the engineering laboratories

of the Massachusetts Institute of Technology. Propelling machinery of modern warships.

The latter has a valuable appendix, giving details of the machinery of eight of the largest English battle ships, and trials under natural and forced draught.

W. F. W.

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS.

VOLUME XVI, Nos. 1 and 2. Fundamental organization of a modern fleet, by F. Attlmayr.

This very interesting article is in the nature of a discussion on an essay by Commander Campbell, R. N., which appeared in the report of the United Service Institution. The author states his own conclusions, which differ somewhat from Commander Campbell's, and gives his reason at considerable length.

Review of maritime legislation and law, 1886–87. The dynamite gun, compiled from different sources, by W. Pucherna. Navigation during foggy weather, translated from *Revue Maritime et Coloniale*, July, 1887. Submarine boats. Estimates for the Imperial Austrian Navy for 1888. Comparative trial trips in Russia with torpedo boats of different builders. Minor Notices: Photographic determination of phenomena in air (preliminary communication by Dr. P. Salcher).

This article outlines experiments which suggested themselves while photographing the disturbances caused by moving projectiles in air. (See Proc. U. S. N. I., p. 263, Vol. XIV, No. 1.) In these experiments the shot remained stationary and compressed air was forced against it.

Ash-hoisting engine with automatic stop, built by "Schiffs und Maschinenbau Aktiengesellschaft Germania" of Berlin. Experiments with electric apparatus whilst under fire of mittrailleuses and small arms (*Rivista Marittima*). French torpedo boats (*Yacht*). Men-of-war for Australia (*Broad Arrow*). American torpedo boat. Trials at Sandy Hook with projectiles loaded with nitro-glycerine (*Admiralty and Horse Guards Gazette*). Fast steam launch "Buzz" (*Engineer*). Experiments with fluid fuel (*Engineer*). Steel armor. Trial trips of the English armor-belted vessel Galatea and the torpedo cruiser "Archer" (*Admiralty and Horse Guards Gazette*). Use of wire cable for moorings. Castor oil as a lubricator. Inspection of Italian merchant vessels for war purposes (*Esercitio Italiano*). The 30 cm. Ordoñnez gun. Damaged guns of the English Navy (*Revue d'Artillerie*). Trials with the Armstrong rapid-firing cannon (*Iron*). The question of small arms in Russia (*Iron*). A new explosive, emmensite (*Iron*). Mortars for coast defense (*Iron*). Bursting of Hope's gun. The 340 mm. De Bange gun (*Rivista di Artiglieria e Genio*). English steel projectiles (*Iron*). Steel shields for infantry (*Iron*). Armor trials in Spezia (*The Army and Navy Gazette*).

Literary Reviews.

Amongst the books reviewed is one entitled "Estado actual de la cuestion torpederas errores pasados y verdades tardias," por Emilio Sellström, teniente coronel di artilleria, Buenos Aires, casa editoria, L. Jacobsen & Cia., 1887. This work is recommended as worthy of the most careful attention, and is reviewed at some length.

E. H. C. L.

NORSK TIDSSKRIFT FOR SOVAESEN.

SEVENTH ANNUAL SERIES, No. 5. Theory of the equilibrium of vessels (conclusion by Prof. J. S. Rasmussen). Hospital ships, their arrangement and their employment in the Navy (Dr. Tybring). Waves (from the *Nautical Magazine*). Loss of the English gunboat Wasp (from *Revue Maritime et Coloniale*). Manufacture of shell for the American pneumatic gun. English rapid-firing cannon. Trials with the Nordenfelt submarine boat. E. H. C. L.

PROCEEDINGS OF THE ROYAL ARTILLERY INSTITUTION.

NOVEMBER, 1887. Dictionary of explosives (continued, by Maj. J. P. Cundill, R. A.)

Gives a list of explosives, both in use and proposed, their ingredients, and in some cases their manufacture. Useful as a book of reference.

DECEMBER. Siacci's method of solving trajectories, by A. G. Greenhill, M. A., and A. G. Hadcock, R. A.

This method differs but slightly from the one explained in the Text-Book of Exterior Ballistics, in use at the U. S. Naval Academy.

JANUARY, 1888. The Maxim automatic machine gun, by Capt. F. G. Stone, R. A.

Of great interest to naval officers. During 1887 four trials on Continent. In first trial, when Maxim gun appeared on the ground the Gardner gun had beaten all competitors. Gardner gun—weight 200 lbs.; tripod, 100 lbs.; 4 men necessary to handle it. Maxim gun—weight 50 lbs.; tripod, 60 lbs.; one man. Gardner fired 300 rounds in 61 seconds; on attempt being made to fire faster, it jammed, causing delay of 15 minutes. Maxim fired 334 rounds in 35 seconds, and made most hits at 300 meters. At another trial, competing against two-barrel Gardner and five-barrel Nordenfelt, it fired 5000 rounds without a hitch; then submitted to a severe sand and rust test, and did not miss a shot.

MARCH. Foreign attempts at making rifles of smaller caliber, by Maj. W. McClintock, R. A.

Comparing the ballistic qualities of small arms now in general use, caliber .45 to .45, with others of reduced caliber, .354, .335, .315 and .295. A great many advantages in favor of the smaller calibers.

Compressed powder charges with central channel were also used in these experiments. M. K. E.

REVISTA MARITIMA BRAZILEIRA.

NOVEMBER and DECEMBER, 1887. Organization of the meteorological services in Europe. External ballistics. The theory of submarine mines. The use of oil on troubled waters. Also a chronicle containing many interesting articles. D. H. M.

REVUE DU CERCLE MILITAIRE.

FEBRUARY 5, 1888. Military schools in Italy. The Italian expedition to Abyssinia, containing an account and plan of a movable fort.

FEBRUARY 12. Military schools in Italy. Rapid fire cannon of large caliber, experimented with in England at Elswick—one of 4⅘-inch bore, throwing a projectile 40 pounds in weight, firing 10 shots in 47½ seconds; a second, of 6½-inch bore, projectile 70 pounds, and firing 10 shots a minute. Charges respectively 12 and 30 pounds of powder.

FEBRUARY 19. Plans for artillery firing. War ships launched during 1887. Military schools in Italy (end).

FEBRUARY 26. Plans for artillery firing. Construction of a new style of torpedoes.

MARCH 4. Plans for artillery firing. List of men-of-war being now constructed in England.

MARCH 18. Study of the methods of instruction for infantry fire.

APRIL 1. Study on methods of instruction for infantry fire. Note on artillery fire in groups. New campaign stove for Russian army.

D. H. M.

REVUE GÉNÉRALE DE LA MARINE MARCHANDE.

JANUARY, 1888. The Newfoundland fisheries. Steam engines: new method of governing the slide in oscillating engines (drawings). Brock's system of quadruple expansion. New style of boiler. Non-explosive boiler (drawings), Roberts'. A perfected dredge, Vernaudon's (drawings). The future of Port Said. The port of Antwerp.

D. H. M.

REVUE MARITIME ET COLONIALE.

FEBRUARY, 1888. An article entitled Tonkin. Instructions for rifle practice in the English and Italian navies, compiled from official documents. Campagne of Rio Janeiro in 1711. Obituary notice of Admiral Jauréguiberry. Chronicle—England. Reforms by the Admiralty. The cruisers Mersey, Brisk, and Narcissus. Discovery of an unknown island.* Coal ships attached to squadrons. United States—Trials of the Chicago. Report of the Secretary of the Navy. The naval war college. Project for a naval reserve. Russia—The fleet in the Black Sea. Artillery—A new explosive substance. The best powder for cannon. The Italian 118-ton gun. Comparison between the 111-ton and 118-ton guns.

MARCH. Hurricanes in Madagascar in 1885. End of the voyage in Senegambia. The Italian Navy in 1888. Chronicle—English ships in course of construction: uses for old ironclads. Reconstruction of the Spanish fleet. The Russian fleet in the Black Sea. The pneumatic gun before the Royal United Service Institution: new English cannon. Speed considered as a factor in naval tactics. Crea-

*Reported by the captain of the Samarang. This island is situated west of islands Salam and Timor, 8° 15′ S., 130° 39′ W. from Greenwich. About 2 miles long NNE., and ⅔ of a mile wide SSW. Low and woody. Not given on any chart.

tion of a Russian war port in the Baltic. The Italian torpedo boat Fatum. D. H. M.

RIVISTA MARITTIMA.

JANUARY, 1888. Historical account of services of Italian seamen under the Spanish flag (continuation). Signal telegraphy. Blockade under present conditions of maritime war. The Quick system of breech-loading cannon (translation from English, with plates). Various professional notes from different periodicals.

FEBRUARY. The Corinth canal.

History of previous attempts to pierce the isthmus, and general description of work now in progress. Time for opening extended from 1888 to 1891, although the promoter, General Türr, looks for the completion of the work in 1890. The voyage from the Adriatic to the Piraeus shortened by 185 sea miles, and that from the Straits of Messina by 95 miles. Amount of merchandise crossing the isthmus in 1881. Advantages to commerce in the increased safety of navigation. General table showing movement of trade in the Eastern Mediterranean in 1885.

Coast defense. The English office of naval intelligence (translation). The pneumatic dynamite gun (translation from English).
J. B. B.

SOCIÉTÉ DES INGENIÉURS CIVILS.

JANUARY, 1888. Solidification of substances under the application of pressures. The consistency and manufacture of cements, mortars, etc. A study of the efficiency of gas engines and the uses of compressed air.

FEBRUARY. The harbor of Saint-Pierre. Reunion Islands. A description of the method now used of welding metals by means of the voltaic arc.

The process, with a short description of its utility and applications. Also a description of a new light of great brilliancy, obtained by burning oil which has been very much rarefied by a current of warm air. It promises wide application to the lighting of work yards, railroad stations, etc., where intense lighting is required for open air work. S. M.

TEKNISK TIDSKRIFT, Utgiven Af Svensk Teknologföreningen.

VOLUME XVIII, No. 1, 1888. Inventions in Sweden from 1870 to 1884. Review of technical instruction given in 1886–1887. Railway to the southern suburb of Stockholm. Triple expansion steam engines. Manganese elements. Patents issued in 1887 in Sweden, Norway, and Denmark. E. H. C. L.

TRANSACTIONS OF THE CANADIAN SOCIETY OF CIVIL ENGINEERS.

VOLUME I, PART II, OCTOBER TO DECEMBER, 1887. Notes on petroleum as fuel; cost as used on the ferry boats at San Francisco, and a useful appendix giving references to articles on petroleum burning. W. F. W.

UNITED SERVICE GAZETTE.

FEBRUARY 4, 1888. Bursting of a 10-inch (38-ton) Armstrong breech-loading gun at Woolwich arsenal.

FEBRUARY 18. Supplement. The Maxim automatic machine gun. Drawings showing the interior of gun, also pictures of the gun in use as field piece, working gun in motion and standing still, gun on tripod, mounted as field piece, and mounted in a wagon drawn by one horse.

FEBRUARY 25. The passage of a river, by Archibald Forster.

MARCH 17. Unsinkable ships.

MARCH 31. Naval mobilization, by Rear Admiral Colomb. A new torpedo boat (No. 49), built by Yarrow & Co.

APRIL 7. The Easter manœuvres—the marching columns.

D. H. M.

LE YACHT.

FEBRUARY 4, 1888. P. 37: The Naval Reserve. P. 41: The accidents to the English torpedo boats. P. 42: Drawings and description of the triple-expansion engines of the steamer Courier.

FEBRUARY 11. P. 47: Life saving boats, system Ponlpiquet. P. 48: Picture and description of Hopkins' luminous buoy. P. 50: View and description of the triple-expansion engines of the yacht Iolanthe.

FEBRUARY 18. P. 53: The Navy in the chamber of deputies. P. 56: Plans and description of the Fatum, a new Italian torpedo boat, built at Leghorn. P. 57: Interesting account of the use of oil on the water in the port of St. Denis, Reunion Island, during a fresh wind which would otherwise have prevented cargo boats going alongside the ship from which the experiments were made. P. 58: View and description of engines for the Queen Victoria, paddle vessel. P. 59: Complimentary notice of the "Pilot Chart" published by the U. S. Hydrographic Office.

FEBRUARY 25. P. 62: The Italian Navy. P. 63: The question of collisions. P. 65: Apparatus for pouring oil on water. P. 67: The road sculler, with description and view.

MARCH 3. P. 71: The speed of the Italia. P. 72: View of two of the four 110-ton guns on the Italia. P. 74: A new means of preserving iron and steel from rust (soapstone, steatite).

MARCH 10. P. 80: Plans and description of a new submarine torpedo boat (electric) invented by Mr. J. F. Waddington.

MARCH 17. P. 85: The English Navy, budget for 1888–89.

MARCH 24. P. 95: Foreign chronicle. P. 96: Plans of a new Spanish torpedo boat, type Azor. P. 97: Description of a new style of compensating compass, by Leon Sirieix, Esq., of San Francisco.

MARCH 31. P. 101: The law in relation to squadrons.

APRIL 7. P. 110: The Navy in the Senate. P. 111: Propulsion by means of hydrocarburet vapor. P. 114: Plans, drawings, and description of the Barcelo, a torpedo boat building at Havre for the Spanish Navy. D. H. M.

REVIEWERS AND TRANSLATORS.

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